



The Impact of Coal Mining on the Environment and Community Quality of
Life: A Case Study Investigation of the Impacts and Conflicts Associated
with Coal Mining in the Mpumalanga Province, South Africa

by

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Executive Summary

Coal is South Africa's major primary energy source, and plays a significant role in supplying the chemicals and steelmaking industries. The benefits of coal production are relevant in the light of South Africa's development priorities of job creation and economic growth. Even so, primary metal production and coal-based power generation industries, through their operations and activities, pose a significant and irreversible risk to the surrounding environment. The impact on the environment further manifests on the health of local communities and on sustainable livelihoods, and frequently also presents a long-term economic burden and loss of valuable resources. Despite changes in legislation and improved social and environmental performance by the industry, there is growing concern over the impacts and conflicts associated with coal mining, with continuing claims by communities and civil society of associated health issues, cattle and livestock death, and destruction of livelihoods. However, to date, little attempt appears to have been made to support community concerns and perceptions with factual evidence and information, suggesting a lack of convergence between lay and expert knowledge.

This dissertation investigates the facts, perceptions, concerns and conflicts in the mine-environment-community cause-effect chain in the context of the environmental and social impacts associated with the South African coal mining industry. More specifically this entails a detailed review of published data on academic literature, newspaper articles, popular magazines, and internet and specialist reports, with particular emphasis on the South African scenario; and semi-structured interviews with representatives from communities, civil society organisations, and independent environmental consultants. Particular focus is placed on coal mining in the Mpumalanga Province, which accounts for over 84% of South Africa's coal production. This was done with a view to developing a better understanding of the interrelationships between the coal mining industry and the local environment and society in which it operates. It is envisaged that this will ultimately serve to facilitate the development of sustainable solutions to the concerns and conflicts associated with coal mining.

Historically, coal mining has had a significant impact on the environment and there is substantial evidence of a strong link between environmental pollution from mining activities and the health and well-being of humans and eco-systems in the surrounding vicinities. These

impacts can be largely associated with water quality, physical and chemical land degradation, and air pollution through dust fall-out and emissions of particulate matter (PM) and toxic gases. In particular, AMD from coal mining results in significant pollution of land and water resources. The published literature provides evidence that this environmental pollution may, and often does, have an adverse effect on local eco-systems as well as on community health and livelihoods, particularly on crop and livestock farming. The findings also indicate that there has been response to these concerns by government and the industry. The government has instituted a number of legislative reforms, particularly since 2002, and has established programmes aimed at improving socio-economic challenges in mining towns. Industry has also taken steps to improve its environmental performance, in terms of waste management, mine water reclamation and post-closure rehabilitation.

The literature findings were found to be largely consistent with the perceptions and concerns of communities, community support groups and consultants active in the coal-mining regions of Mpumalanga Province. The perceptions of the coal mining and processing sector were extremely negative; all participants expressed considerable concern over the environmental and social impacts. Emissions, particularly AMD and dust, from current and defunct workings and waste piles continue to be a source of water pollution, air pollution and land degradation which further have an adverse effect on aquatic life and human health as well as on livestock and crop productivity. Of particular concern in the coal-mining intensive area of Mpumalanga, is the impact of environmental pollution on maize production. With increasing public knowledge and awareness of these impacts, which can be largely attributed to the activities of the relatively large number of civil society organisations that now exist, the concerns and incidents relating to the environmental and socio-economic impacts from coal mining in the Mpumalanga area are generally well reported.

The general consensus was that the concerns of communities and community-support organisations are not been taken seriously, and that government and industry are failing to alleviate the environmental degradation and human suffering in the Mpumalanga coal-mining areas. The lack of adequate response on the part of both the government and industry, and the continuing issues of environmental pollution and adverse community effects, have resulted in on-going (and possibly escalating) conflict situations in the form of community activism, protests and litigation. This lack of response from government was, furthermore, considered as highly politicised and attributed largely to unethical arrangements between government

officials and/or community leaders and mining corporations. Participants were generally of the perception that the negative aspects of coal mining outweigh any benefits and should be discontinued completely.

The findings of this dissertation suggest that effective rehabilitation, consistent implementation and enforcement of the regulations designed to protect the environment and society, and stakeholder collaboration are a key requirement in terms of mitigating the environmental impacts and associated risks pertaining to human and livestock health and crop productivity. It is therefore recommended that the government address the rehabilitation of abandoned coal mines and discard dumps in the Mpumalanga Province, and establish action plans, linked to regional development plans, that are based on a comprehensive environmental monitoring programme in collaboration with other stakeholders, including communities, the mining industry and other business sectors in the region. A more detailed study on opportunities to improve the quality and availability of performance reporting by the coal industry is also recommended.

Statement of Originality

DECLARATION

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Abbreviations and Acronyms

AMD	Acid Mine Drainage
BECSA	Anglo Coal BHP Billiton Energy Coal South Africa
CCS	Centre for Civil Society
CER	Centre for Environmental Rights
CBAs	Critical Biodiversity Areas
COPD	Chronic Obstructive Pulmonary Disease
CMDLD	Coal Mine Dust Lung Disease
CSO	Civil Society Organisations
CSIR	Council for Scientific and Industrial Research
CWP	Coal Workers' Pneumoconiosis
DEA	Department of Environmental Affairs
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DMR	Department of Mineral Resources
DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Programme
EMPR	Environmental Management Programme Report
EWRP	Emalahleni Water Reclamation Plant
FEPAs	Fresh Water Ecosystem Priority Areas
GDP	Gross Domestic Product
IDP	Integrated Development Plan
ICMM	International Council on Mining and Metals

MCEJO	Mfolozi Communities Environmental Justice Organisation
MMSD	Mining, Minerals and Sustainable Development
MPRDA	Minerals and Petroleum Resources Development Act
NWA	National Water Act
NEMA	National Environmental Management Act
PM	Particulate Matter
RBCT	Richards Bay Coal Terminal
ROM	Run-of-Mine
SACRM	South African Coal Road Map
SDGs	Sustainable Development Goals
WRC	Water Research Commission
WCI	World Coal Institute
WRI	World Resources Institute
WUL	Water Use Licence

CHAPTER 1

INTRODUCTION

South Africa is well endowed with vast mineral resources of international value and the wealth created through mining, particularly gold mining, has funded the development of the country (McCarthy, 2011). These resources provide raw materials for rapid industrialization and generate a sizable amount of employment opportunities for local people (Hota and Behera, 2015). Within South Africa, coal is used primarily by Eskom to produce electricity and by Sasol to produce liquid fuels and chemicals (SACRM, 2011). Given current and planned power generation expansion in the country, domestic coal consumption is expected to grow. The extraction of mineral resources also brings other benefits to nearby communities as well as schools, hospitals, construction, and improved transportation and communication facilities. Even so, primary metal production and coal-based power generation industries, through their operations and activities, pose a significant and irreversible risk to the surrounding environment. The impact on the environment further manifests on the health of local communities and on sustainable livelihoods, and frequently also presents a long-term economic burden and loss of valuable resources—termed the ‘resource curse’. Research has shown that the longer-term impacts of these industries and especially coal mining are far more likely to be severe in South Africa than in other countries, because of the unique combination of geography, climate, population distribution and the scale of the deposits (McCarthy, 2011).

This research study looks into the relationship between mining operations, environmental degradation and community quality of life in South Africa, with a focus on the impacts and conflicts associated with the coal mining sector. The overarching aim is to generate knowledge to support the development and implementation of sustainable approaches to mitigate the long-term risks and burdens associated with the coal mining industry. This chapter provides contextual background information, presents the research problem and key questions to be addressed, and outlines the scope of the study.

1.1 Background

1.1.1. Overview of the South African Coal Mining Industry

Coal is one of the world's most used resources and, despite the debates around climate change, global patterns of coal consumption have changed dramatically over recent years with coal reported to be far from being in decline (World Atlas, 2015; SACRM, 2011). China is the lead producer of coal in the world with the United States coming second. Having traded about 74 million tons of coal in 2012, South Africa is ranked the seventh largest global coal producer and sixth largest coal exporter (World Atlas, 2015). Coal is the country's major primary energy source and plays a significant role in supplying the chemicals and steelmaking industries (SACRM, 2011).

- ***Legislation and Regulation of Coal Mining***

The South African government is the custodian of all natural sources in the country, including mineral resources. Chapter 2 of the Bill of Rights in the Constitution of the Republic of South Africa, 1996, section 24 (b) (iii), has a provision that *"Everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development"* (Diale, 2014). The Minerals and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002), administered by the National Department of Mineral Resources (DMR), is the central piece of legislation regulating the mining industry in South Africa; it provides guidance on how the prospecting, quarrying and production of minerals in South Africa should take place (Bench Marks Foundation and Bread for All, 2015). The legislation supports public participation, promotes transformation within the minerals and mining industry, promotes equitable access to minerals, and focuses on developing black ownership of mines (Bench Marks Foundation and Bread for All, 2015; Diale, 2014). The Act further requires mines to develop an Environmental Management Programme Report (EMPR), with an environmental management plan stipulating monitoring and evaluation arrangements, and financial plans guaranteeing social and labour plans, as well as mine rehabilitation and closure. The MRPDA is generally perceived as a good Act, although there are problems relating to its interpretation and implementation (SACRM, 2011). For example, it has always been criticised for not setting sufficient regulations— current repercussions concern the

addition of the term ‘where necessary’ under the Water User Licence (WUL) for mining in the Amendment Bill. Responses to the amendment have been unpleasant, with many stakeholders expressing their concern that the addition of this term will open the door for abuse by the applicant or the regional manager by awarding them, in terms of the new Bill, with unwarranted decision-making powers to choose when applications for a WUL are necessary and when they are not (Bench Marks Foundation, 2014). Even so, the Amendment Bill was cleared by the National Council of Provinces and passed on to President Jacob Zuma to sign into law (Bench Marks Foundation, 2014).

In his report on the social and environmental consequences of coal mining in South Africa, Munnick (2010) highlights the National Water Act (NWA) (Act 36 of 1998) and National Environmental Management Act (NEMA) (Act 107 of 1998) as significant legislation for the mining industry. NEMA is enforced by the Department of Environmental Affairs and Tourism (DEAT); its provisions are complementary to the NWA and require the prevention and/or rectification of pollution through the undertaking of Environmental Impact Assessments (EIAs) and Environmental Management Programmes (EMPs) for activities that affect the environment. The NWA regulates the use of mining water and the protection of the resource, and supports the ‘Polluter Pays Principle’ which stipulates that mines should take responsibility for their pollution. Section 19, which is entitled "Prevention and remedying effects of pollution", states: “ *An owner of land, a person in control of land or a person who occupies or uses the land on which- (a) any activity or process is or was performed or undertaken; or (b) any other situation exists, which causes, has caused or is likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring*” (Feris and Kotze, 2014).

The SACRM (2011) notes that “*South Africa’s mining, energy, transport and environmental policies, in line with its Constitution, are amongst the best in the world and aligned with a 21st century agenda*” . The White Papers and strategies developed since 1994 are forward looking and inclusive, and inspire optimism and confidence. However, the country falls short in terms of implementation of these policies. Although it operates under progressive legislation, the South African government is said to have a pro-mining policy and a weak regulation system, such that the legislation is not easy to enforce in practice (Munnick, 2010; Bench Marks Foundation and Bread for All, 2015). The failure to enforce and implement

legislation is attributed to the large degree of intergovernmental cooperation that is required and capacity constraints.

- ***Coal Production***

Coal mining is a mature industry in South Africa and the economy depends heavily on it, both as a source of foreign income and as a primary source of energy (Reddick et al., 2008). The first discovery of coal in South Africa was in 1699 at Fransch-Hoek in the Western Cape (Peatfield, 2003). Coal mining began in the 1880s, following the discovery of the Kimberly diamond fields and the growth of the gold mining industry. The gold mines needed energy to transport heavy machinery and labour in and gold out to the ports (Groundwork Report, 2016) and coal played a supportive role as the provider of this energy (Munnick, 2010). As such, many coal mines were and still today are owned by gold mining houses (Eberhard, 2011; Munnick, 2010). Initially, coal mines had relatively low levels of mechanisation and extraction rates (Eberhard, 2011). When the rail and port systems were developed in the 1970s, the production and export of coal increased sharply whilst the coal price remained low (Munnick, 2010). The demand for coal parallel to that for rose dramatically in the 1970s, resulting in the expansion of the industry and the creation of more coal mines (Pone et al., 2007). The Witbank coalfield developed in the 1890s and became the principal source of power for the country's industries, mines and rail system (Peatfield, 2003). Mpumalanga Province (then the Transvaal Province) became the major home ground for coal mining to supply the growing number and size of power stations as the gold industry burgeoned and the demand for power increased (Peatfield, 2003). Coal demand (and electricity generation) grew rapidly. Meanwhile, the colliers relied on cheap labour to produce the cheap coal (Groundwork Report, 2016).

South Africa has the fifth largest coal deposits in the world which occur in 19 coalfields (shown in Figure 1-1) located mainly in Mpumalanga, Limpopo and the Free State, with smaller reserves in KwaZulu Natal, Gauteng, the North West Province and the Eastern Cape. Current reserves are estimated at 66.7 billion tonnes Run-of-Mine (ROM) indicating an increase of 21% since the 55 billion tonnes estimate figures of 1987 (Hancox, 2016).

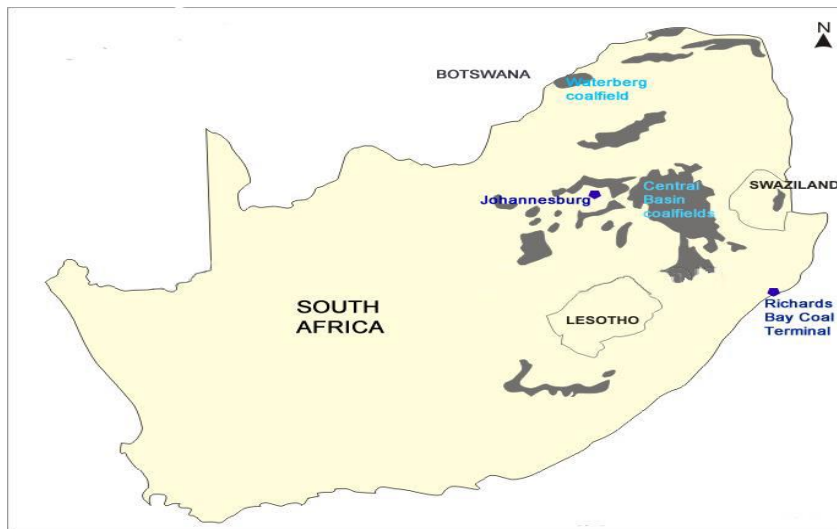


Figure 1-1: Coalfields of South Africa (Bench Marks Foundation and Bread for All, 2015)

The majority of the reserves and operating mines are currently in the Central Basin (which includes Witbank, Highveld and Ermelo coalfields located in Mpumalanga and Gauteng Provinces), and Limpopo and KwaZulu Natal, where smaller operations are found (Bench Marks Foundation and Bread for All, 2015; Jeffry, 2005). More than 50% of the country's saleable coal comes from the Witbank coalfield (Hancox, 2016). The Waterberg and Soutpansberg coalfields, located in Limpopo Province, have vast resources, mostly unexploited. The Waterberg coalfield is the focus of recent exploration efforts and could become a major coal mining centre in the future, subject to infrastructure and water constraints (Eberhard, 2011). In 2000, it was estimated that 15% of the country's GDP was spent on energy, of which 77% was derived from coal (Bench Marks Foundation and Bread for All, 2015). In 2006, coal accounted for 93% of electricity generated in South Africa, followed by nuclear (4.6%) and hydropower (2.2%) (Bench Marks Foundation, 2015). In 2010, the Mpumalanga Province accounted for over 84% of South Africa's coal production (Mining Weekly, 2010). Since then, coal production has remained stagnant in the leading coalfields of Witbank, Ermelo and Highveld due to the depletion of coal reserves as well as operational and technological constraints (Pooe and Mathu, 2011; Jeffrey, 2005b).

As at 2014, South Africa was the largest coal producer in Africa with total production estimated at 333.6 million tons (Hancox, 2016). Of the coal produced, 85% comes from the major coal producers, namely Anglo American's Thermal Coal business unit, Exxaro, Sasol mining, BHP Billiton (now South32), and Glencore Xstrata (details on mines and production

appear in Appendix D). There are about 120 junior coal producers in South Africa, most of whom are mining old underground mines (Groundwork Report, 2016). The junior producers include Optimum Coal, Umcebo Mining, Siyanda Coal, Kangra, Shanduka, Coal of Africa, Anker Coal and Riversdale (SACRM, 2011). Anglo American, which has its origins in gold mining, has been South Africa's largest company, and remains a major coal producer (Eberhard, 2011). In 2015 Anglo American mines produced a total volume of 50.3 Mt, with export production totalling 17.4 Mt (<http://southafrica.angloamerican.com>). Anglo American owns and operates eight mines, four of which supply Eskom. Three of these mines, namely the New Denmark, New Vaal and Kriel, along with four closed collieries, were recently sold to Seriti Resources Holding, a black-owned company (Mining Weekly, 2017). The export markets are largely dominated by major producers, while the juniors may sell to the majors even when they have a share in the Richards Bay Coal Terminal (RBCT) (Groundwork Report, 2016). The junior producers therefore account for only 7% of national production (Groundwork Report, 2016).

- ***Coal Mining and Preparation Operations***

The method used to mine coal is determined by the geology of the coal deposit and based on economic considerations (WCI, 2009). According to Munnick (2010), approximately 51 % of South African coal mines are underground and 49% open-cast (or open-pit). In open-cast mining, the soil cover is scraped off and stock-piled (McCarthy and Pretorius, 2009). Before coal extraction, a large area of the coal deposit is then exposed by removing the covering rock (the overburden) from the mined area usually using trucks and mechanised shovels or bucket-wheel excavators. *“The overburden of soil and rock is first broken up by explosives; it is then removed by draglines or by shovel and truck. Once the coal seam is exposed, it is drilled, fractured and systematically mined in strips”* (WCI, 2009). The broken rock is then returned to the pit, the site is landscaped, the soil is returned, and grass is planted.

Underground mining is used when the coal seams are too deep (>40m) to remove the overburden (Lloyd, 2002). Two methods are employed: room-and-pillar mining and long-wall mining. Room-and-pillar mining entails the cutting of a network of rooms into the coal seam and leaving behind pillars of coal to support the roof of the mine. Long-wall mining recovers and extracts a high percentage of the coal and can be very costly. It involves the full extraction of coal from a section of the seam or face using mechanical shearers (WCI, 2009). The shear is passed across the exposed face of the seam and shears away broken coal which

is hauled away by a floor-level conveyor system (<https://www.nap.edu/read>). The roof is allowed to collapse when the coal has been extracted from the area. According to Lloyd (2002), in South Africa only about 5% of the underground coal is mined by long-wall mining due to the fact that the seams are generally not consistent.

Coal received directly from mining sites or ground is called Run-of-Mine (ROM) and contains certain proportions of unwanted impurities such as rock, dirt, ash forming minerals, and mining fragments (WCI, 2009; Kotelo, 2013). These materials reduce the energy content or heating (calorific) value of the coal, increase the volumes of material to be handled and transported, increase the wear and tear on handling and combustion equipment, and result in hazardous gaseous and particulate emissions during combustion (Broadhurst et al., 2016). The preparation, i.e. cleaning or processing of ROM coal, entails the removal of these unwanted impurities, thereby generating a uniform product that is more suitable for transport and commercial markets. Coal preparation involves three processing stages namely: crushing, screening and washing. The ROM coal is first crushed to an acceptable top size for treatment in the preparation plant. In the screening stage, the crushed coal is screened to remove large foreign objects and separate the coal into various size fractions, either for direct sale or for further processing by washing (Broadhurst et al., 2016).

Coal washing, also known as coal beneficiation, is conducted to reduce the content of ash-forming minerals, thus meeting product specifications that cannot be achieved by screening alone. Coal is typically washed using density separation techniques, which rely on differences in density between the inorganic, ash-forming minerals and the valuable carbon in the coal (Broadhurst et al., 2016). According to Peatfield (2003), coal for electricity generation is generally unwashed, whereas coal for local trade and exports is beneficiated with an average yield of 60–65% and a calorific value (CV) of ± 28 MJ/kg, (air dried). In South Africa however, statistics reported in 2007 indicate a considerable decline in the proportion of washed ROM ore in comparison with 2002/2004 data which indicated that between 80 and 85% of the ROM was washed in some 60 washing plants (de Korte, 2004 ;Reddick, 2016). The waste from coal washing or preparation occurs in two main forms, namely: discards, and ultra-fine slurry streams (Kotelo, 2013). Coal discards can be defined as the solid wastes from coal cleaning that are of insufficient commercial value due to their high ash content/low calorific value, whilst ultra-fine coal slurry is the fraction of coal which is too fine to be effectively beneficiated using conventional techniques (Broadhurst et al., 2016). The discard

contains high ash and sulphur and is therefore of poor quality, and presents environmental challenges, although it is a potential resource for power production using fluidized bed combustors (Eberhard, 2011).

The processed coal is used primarily by Eskom to produce electricity and by Sasol to produce liquid fuels and chemicals but a large volume of it is exported to other countries (mostly Europe, China and India) through the RBCT (SACRM, 2011). Eskom's coal consumption has been increasing and since 2007 South Africa has been experiencing power shortages. Other small-sector users include steel and iron production and manufacturing.

1.1.2 Challenges Facing the South African Coal Industry

The coal industry has been subject to constant criticism because of its environmental impacts even while the benefits of coal production are relevant in light of South Africa's development priorities of job creation and economic growth (SACRM, 2011). This suggests a trade-off between the need for development and that for cheaper and affordable energy. Coal production is currently being increasingly displaced by less carbon-intensive energy sources, such as gas, nuclear and renewables, and global patterns of coal consumption are changing dramatically. Global pressures have prompted the drive towards a greener economy, particularly towards cleaner energy sources, parallel to the increasing demand for coal. Whilst coal production and utilisation remain significant, there is pressure on the coal industry to reconsider its impacts and mitigation responses, especially relating to climate change mitigation, in order to improve its sustainability. Improving the sustainability of the industry has implications for the current policies in terms of consistency, and further presents several other challenges and risks, such as that of ensuring adequate coal supply, competitiveness, and financial costs (particularly relating to infrastructure) in undertaking the required actions to mitigate impacts.

- ***Sustainability of the Coal Mining Industry***

South Africa's National Development Plan and New Growth Path prioritise sustainable development through provisions for addressing issues of societal transformation, economic growth and development, and environmental protection. Equally, the Sustainable Development Goals (SDGs) seek to achieve social inclusion, environmental sustainability and economic development by 2030. Moreover, the CSIR, Mintek, and the Council for Geosciences were tasked by the DME (now DMR) to develop a strategic framework and

vision for sustainable development (SD) through the Sustainable Development in Mining Initiative programme (DME, 2007). This was after the World Summit on Sustainable Development in 2002 which saw the South African minerals and petroleum sector contributing optimally to SD by 2010 (DME, 2007).

However, the need for sustainable development is in conflict with the increased need for energy, which requires increased exploitation of natural resources. The South African coal industry faces many challenges which have been expressed by the National Planning Committee and in the Coal Roadmap (SACRM, 2011). The current energy crisis explains the then President of the South African Institute of Mining and Metallurgy's 1999 notion that the current reserve and resource estimates were not adequate for informed projections on the future of the coal industry (Hartnady, 2010). Hartnady (2010) further highlights that given South Africa's heavy dependence on coal for power generation and electricity supply, the economic situation appears to be heading rapidly towards a state of severe permanent crisis, which will be exacerbated by the low level of coal production at peak 2020: the demand for electricity will soon outstrip supply. The Witbank and Highveld coalfields are nearing exhaustion while the coal quality and mining conditions in the Waterberg, Free State and Springbok Flats coalfields are significant barriers to immediate, conventional exploitation (Jeffrey, 2005b). The coal mining industry seems to be in a roller-coaster ride with depleting reserves and concurrent environmental and social footprints which continue to constrain developmental efforts.

Following these reports, the South African Coal Roadmap study (SACRM, 2011), a collaborative initiative between the South African government, Eskom, Sasol, coal producers and other stakeholders, was initiated to explore the state of the country's coal industry and the issues it faces, and to develop a clear roadmap of the preferred path for the industry (SACRM, 2011). The SACRM (2011) study recognises the benefits arising from the coal industry in terms of income, employment, energy and the potential for continued economic benefit and energy security, but also identifies a downside. Many of the critical challenges outlined in the SACRM reports are of an institutional nature: firstly, it was reported that the resource and reserve information is not up to date and, secondly there is no integrated coal policy. Further, it was reported that the country has no master energy plan, no organised coal association, and no clear export strategy, giving the impression that there is no clarity on the outlook for the industry (SACRM, 2011). Also highlighted were climate change pressures;

the availability of infrastructure, and resources such as water; access to financial capital investment; and the continued adverse impacts of coal mining on the local environment and surrounding communities (SACRM, 2011). As the reserves of the central coalfields become exhausted and focus shifts to the richer northern coalfields in Limpopo, these challenges are likely to increase. This is due to a combination of challenges associated with the Limpopo coal reserves and the geo-political climate, particularly the low-grade, depth and geological complexity of the deposits, severe water shortages, insufficiently developed infrastructure, and fragile natural environment (Jeffrey, 2005a; Jeffrey, 2005b).

As per the provisions of the National Development Plan and New Growth Path, the issues concerning the long term sustainability of mining communities will also need to be considered. Mitigating the negative impacts whilst enhancing the positive impacts is an important sustainable development goal.

- ***Environmental and Social Impacts of Coal Mining***

The perceived low cost of coal still makes it a dominant source of power (Morrice and Colagiuri, 2013). However, while it contributes significantly to worldwide energy generation, its environmental and socio-economic footprint is still a challenge. It is identified as being affordable, reliable, secure and valuable (SACRM, 2011); yet it is also considered a dirty source of energy because of its impacts. These impacts include land disturbance and loss, subsidence, AMD, dust, excessive generation of greenhouse gases, increased traffic, noise, vibration and water pollution all of which occur during mining (SACRM, 2011; Moffat and Mulloli, 2003; Morrice and Colagiuri, 2013; CER, 2016b). The connection between the environment and human health has long been acknowledged and the negative effects of coal production are primarily manifested in environmental damage and detriments to health and wellbeing (Morrice and Colagiuri, 2013). The impacts are cumulative and often only manifest themselves after extended periods when production is waning or after mine closure. The related impacts not only affect local communities but also pose management challenges for mining companies and regulatory agencies (Sonter et al., 2014). In the face of these challenges, some European countries have rendered coal mining as obsolete, with France closing all coal mines in 2004.

Changes in legislation have been put in place alongside the development of waste management approaches, but it is becoming increasingly recognised that despite stringent legislation and conventional waste disposal techniques, South Africa still experiences

inadequacy in addressing the potential risks associated with biodiversity losses, environmental degradation, and the consumption of natural resources such as land and water, as well as the health and socio-economic impacts on local communities. In its Zero Hour report, the Centre for Environmental Rights (CER, 2016b) expressed its concern over poor governance, based on an in-depth review of evidence from the Mpumalanga Province. In accordance with the CER (2016) report, the South African government is failing to ensure that mining companies comply with the law and, as such, communities and the natural environment are paying an indefensibly high price. ActionAid (2014) attributes this failure to a huge imbalance of knowledge and power between corporate and community stakeholders. These negative environmental and social impacts of mining have often led to mine company-community conflicts, which have received a great level of attention by advocacy organisations and traditional and social media (ICMM, 2015). Local communities' reactions to these impacts can escalate from complaints to protests and road blockages, which may further lead to injury or death resulting in significant costs for both the community and the mining company (GroundUp and Davies, 2014).

The mining company-environmental community relationship is, however, complex and is influenced by a number of factors. In their study to explore the health and environmental concerns associated with open-cast mining, Moffatt and Mulloli (2003) found that the factors related mainly to the proximity of the mine to housing and farmland, and the length of operation. Furthermore, their findings indicated that socio-political issues may also play a big role in influencing perceptions, concerns and conflicts. For instance, at the time of their study, concerns regarding national asthma levels were prevalent in the UK, giving rise to fears and concerns from parents living close to open-cast mines (Moffatt and Mulloli, 2003). Based on direct experience, many suspected a causal link with air pollution, later not found to be the case. Similarly, in their paper on coal mining, social injustice and health, Morrice and Colagiuri (2013) conclude that the nature and intensity of impacts may vary according to national differences in mining methods and/or volume of coal extracted, suggesting that they cannot be generalised. Their study finds the health and wellbeing of local coal-mining communities to be increasingly highly politicised and contested between health and social justice versus a profitable mining sector and robust economic growth. They describe this as “conflict of power and priorities” and report that even where evidence is available to support

arguments, this is seldom used to inform public debate (Moffatt and Mulloli, 2003; Morrice and Colagiuri, 2013).

1.2 Problem Statement

Coal mining and processing remains a significant activity in certain parts of South Africa, particularly in the Mpumalanga Province. Despite changes in legislation and improved industry, social, and environmental performance, there is growing concern over the impacts and conflicts associated with coal mining, with continuing claims by communities and civil society of associated health issues, cattle and livestock death, and destruction of livelihoods. The justification for, and the development and implementation of, sustainable solutions to address these impacts needs to be underpinned by a detailed understanding of the causal relationships between coal mining, environmental degradation and community impacts. However, to date, little attempt appears to have been made to support community concerns and perceptions with factual evidence and information, suggesting a lack of convergence between lay and expert knowledge.

1.3 Project Scope

1.3.1 Project Objectives

The overarching objective of this study is:

To investigate the facts, perceptions, concerns and conflicts in the mine-environment-community cause-effect chain, in the context of the environmental and social impacts associated with the South African coal mining industry.

This will be done with a view to developing a better understanding of the interrelationships between the coal mining industry and the local environment and society in which it operates. It is envisaged that this will ultimately serve to facilitate the development of sustainable solutions to the concerns and conflicts associated with coal mining.

More specifically, this study sets out to:

1. Review and critically analyse the relevant literature, data and information pertaining to the environmental and social impacts of primary coal production in South Africa; associated conflicts between local coal mining companies and communities; and the actions taken by various stakeholders to address these impacts.

2. Establish the perceptions, understandings, concerns and aspirations amongst communities and community-support organisations with regards to the mine environment-community cause-effect chain.
3. Assess issues of information, communication and responses in terms of these concerns.
4. Identify gaps and opportunities in terms of understanding and addressing the causal relationships between coal mining, environmental degradation and community quality of life.

This study forms part of a broader project sponsored by the Water Research Commission (WRC) titled “Resource Efficient and Socially Responsible Approaches for the Integrated Management of Mine Wastes: Understanding the Opportunities, Enablers, Barriers and Risks”, under the leadership of Associate Professor Jennifer Broadhurst.

1.3.2 Scope of Work

The study is qualitative and applies a combination of desktop review and case study fieldwork approaches. The scope of work is conducted in two phases:

Phase 1 entails a detailed review of published data in academic literature, newspaper articles, popular magazines, and internet and specialist reports, with a view to meeting the first aim of this study. Particular emphasis will be placed on, but not restricted to, the South African scenario.

Phase 2 entails semi-structured interviews with representatives from communities, civil society organisations and independent environmental consultants, with a view to meeting the second and third aims of the project. For this purpose, a questionnaire was designed consisting of pre-set variables, from which participants will rate their responses using a Likert scale, and simple comprehensive open-ended questions. Here the focus is on coal mining in the Mpumalanga Province, which accounts for over 84% of South Africa’s coal production.

It should be emphasized that the objective of this study is to obtain perspectives of local communities and organisations representing community interests, and as such the views and perceptions of mining companies and government are not included. Whilst these perspectives are analysed in the context of current government and company activities, this is only based on publicly available documents. It should also be noted that the study is only concerned with

the impacts and effects arising from coal extraction and primary processing. The impacts associated with coal-based electricity production have not been included.

1.4 Dissertation Structure

A schematic showing the structure of the dissertation is presented in Figure 1-2. Chapter 1 provides an introduction and sets out the project objectives and scope. Chapter 2 provides a summary and analysis of the available literature, consistent with the scope of work for Phase 1 of the study. The results of the interviews with relevant stakeholders (Phase 2 of the study) are presented and discussed in Chapter 3, whilst Chapter 4 assimilates the findings of phases 1 and 2, drawing final conclusions and making recommendations for future actions and studies.

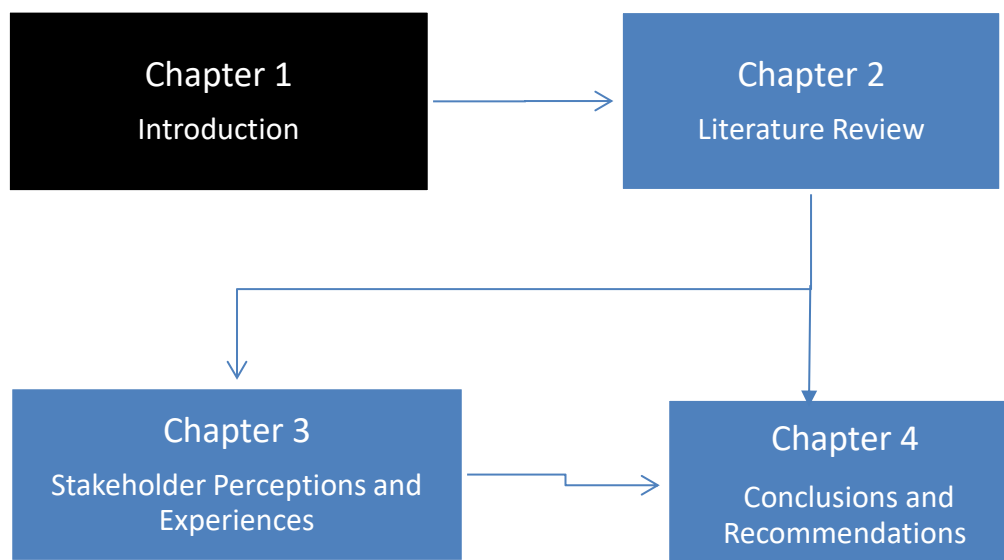


Figure 1-2: Dissertation structure schematic

CHAPTER 2

LITERATURE REVIEW

In South Africa, mineral development dates back to the eighteenth century, when gold was discovered, and has contributed significantly to the economic growth in the country in the past. However, the benefits are not always equitably shared and local communities closest to the source of mineral development can suffer the most (WRI, 2014). As indicated in Chapter 1, this is particularly so in the case of the South African coal mining industry, with the extraction and processing of coal impacting on the surrounding environment and the health and livelihoods of the local community.

This chapter presents a detailed review and assessment of literature on the impacts of coal mining that relate to environmental degradation and community quality of life (health and livelihoods). This theoretical base draws on i) published scholarly opinions on the impacts of coal mining on the environment and community quality of life, and ii) published reports including company reports on cases of pollution, concerns, conflicts and responses pertaining to coal mining communities. Consistent with the first key aim of this study, the literature and information review and analysis include the environmental and social impacts of primary coal production both within South Africa and globally (Section 2.1). Also covered are specific incidents and conflicts between local coal mining companies and communities (Section 2.2), and the actions taken by various stakeholders to address these impacts (Section 2.3), with an emphasis on the South African context, particularly the Mpumalanga area.

2.1 The Environmental and Social Impacts of Coal Mining and Beneficiation

Coal is a strategic asset for South Africa but is also subject to significant resource constraints (SACRM, 2011). Initially, there was little environmental degradation associated with mining activities (Bell et al., 2001), but when the coal trade began to dominate regional economies in mining districts, its negative impacts came to be accepted as a necessary by-product of the generation of coal-based wealth (Younger, 2004). Today, there is growing concern, supported by a substantial body of evidence, that coal mining and processing impact negatively on the

local environment and on human health and livelihoods. The social and economic impact on rural communities is no longer considered acceptable and has gained considerable attention from social scientists, civil organisations, communities and academic researchers. The debate about mining-related social, environmental and health injustices remains eminently salient while the demand for coal-powered energy generation remains significant despite the current drive to renewables. This section summarises the direct environmental emissions and impacts (Section 2.1.1) and the effects these may have on ecosystems (Section 2.1.2) and on local communities in terms of human health (Section 2.1.3) and livelihoods (Section 2.1.4).

2.1.1 Environmental Impacts

The coal energy system (as shown in Figure 2-1) comprises coal mining, preparation or processing, and energy generation, with environmental issues occurring at every stage of the process —what is referred to as its ‘chain of custody’(Zhengfu et al., 2010; CER, 2016b). This study will focus on the coal mining and preparation activities as described in Chapter 1. These operations make a notable impact on the environment (Bell et al., 2001), including land disturbance (subsidence, appearance of tension cracks at the surface, crown hole development), spontaneous combustion and deterioration in the quality of the surrounding water, air and soils.

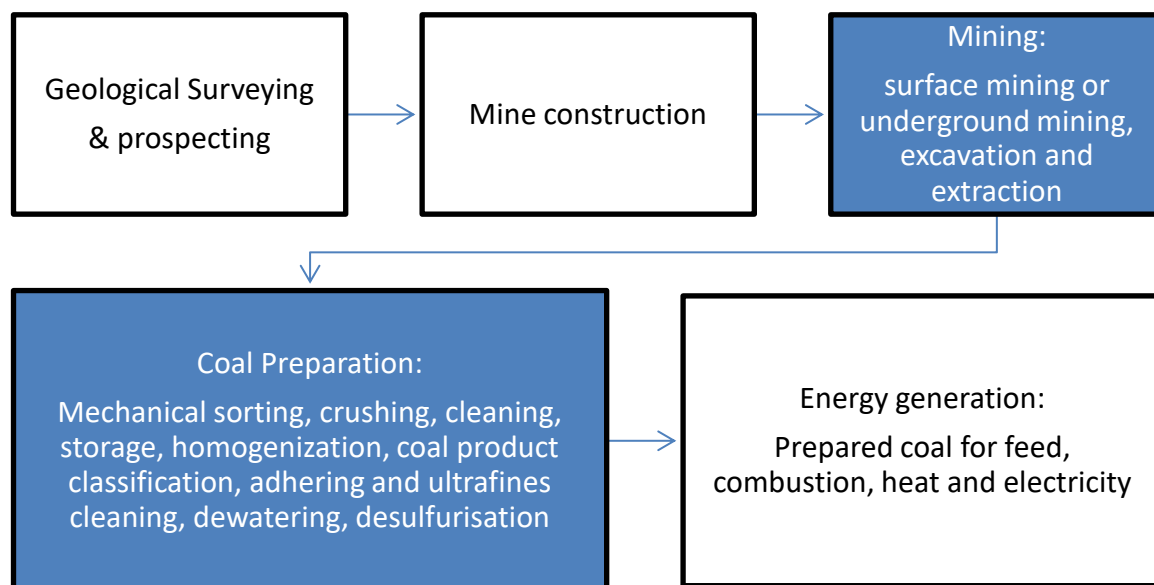


Figure 2-1: Coal energy system (Zhengfu et al, 2010) showing the operations included in this study (blue-shaded blocks)

- ***Land disturbance***

Coal mining is a significant driver of land disturbance where economic coal seams and coal mining methods are applied (Lechner et al., 2016). The most obvious indicator of land disturbance is that of land occupation. Mining, particularly open-cast mining sites, take up considerable land before, during extraction, and through the commodity's life cycle until after the mine closes (Figure 2-2). In Mpumalanga, for instance, coal mining accounts for 24.5% of land use and 54.2% is reported to be under prospecting (Demacon Market Studies, 2016).



Figure 2-2: View of open-cast coal mines showing the extent of land disruption (GDACE, 2008; https://en.wikipedia.org/wiki/Mining_engineering, 2017)

Land occupation and deforestation occur as a result of excavations, erection of supporting and processing infrastructure, and the disposal of waste in the form of overburden, discards and slurry (Bell et al., 2001; Sonter et al., 2014; Zhengfu et al., 2010). By nature, mining activities produce large amounts of waste and the amount produced is dependent on the type of mineral extracted and the size of the mine (WRI, 2014). In accordance with the SACRM (2011) report, approximately 20 – 22% of the ROM coal reports as total discards, of which 4 – 6% is in the form of ultra-fine slurry. Apart from forming blemishes on the landscape, overburden and discard dumps contain coal, and if not properly compacted, allow penetration of air and water, which can result in spontaneous combustion and the development of acid mine drainage (Bell et al, 2001). The dumping of waste during mining operations affects the land in the vicinity of the operations and this land is prone to surface erosion which may increase sediment loading to surface waters (Mangena and Brent, 2006). Appendix E presents a list of minor and trace elements reported to occur in South African

coals, their associated minerals, and typical characteristics of coal discard and tailings. Whilst land disturbance makes a significant impact, of greater environmental concern are the indirect impacts on air and water quality, discussed in subsequent sections below.

Another direct land disturbance from coal mining is land subsidence, which is typically linked to underground mining, whereby the ground level lowers as a result of coal having been mined beneath. According to Zhengfu et al. (2010), coal mining in China has caused the destruction of land resources and the fragmentation of the landscape accompanied by land desertification. They report that in a local coal mining area located in eastern China, farmland had decreased by 13% from 1997 to 2001 and flooding resulting from mining subsidence had increased by 138% whilst (mining) construction areas increased by 38% (Zhengfu et al., (2010). Mining subsidence will affect land use such as crop production and will induce slope failure causing the loss of water and soil through the formation of surface cracks and overburden fracture from mining (Zhengfu et al., 2010). In the Witbank Coal field, subsidence has been found to cause collapse and flooding in places (Bell et al., 2001). Similar observances were made in eastern China, where flooding of prime farmland was caused by mining subsidence. After the mining subsidence, land use was changed as buildings, roads and croplands were seriously damaged (Zhengfu et al., 2010).

Land disturbances can also be indirect and extend beyond the mining site. Soils can be degraded off-site due to dispersion of dust and contaminated water from operations and waste dumps. Sonter et al. (2014) also reported that mining operations can indirectly influence adjacent land users. According to Limpitlaw et al. (2005), degraded lands can potentially support fewer land uses —no crop production, for instance. Land use change as a result of coal mining results in reduced crop production, utility failures, plant death, surface fracture, soil loss, drainage system failure and building damage (Zhengfu et al., 2010). Van der Burgh (2012) reported a significant impact from coal mining on the arable soils and agricultural activity in general, stipulating that approximately 12% of soils had been transformed by coal mining activities, with an additional 13.6% subject to coal prospecting applications. Sonter et al. (2014) conducted a land use change analysis within a large and well established mining region in Brazil which had undergone 20 years of land-use change. Their investigation mainly aimed at finding the causes and consequences of observed changes. The study confirmed that mining regions undergo abrupt and extensive land use change (Sonter et al., 2014), and the processes of land-use change are distinct from those in non- mining regions.

However, they also found it necessary to consider evidence and experience learnt from other mining regions. This was based on the realisation that no comparisons have been made with non-mining regions to examine differences nor with other mining regions.

- ***Air Pollution***

Air and noise pollution have local, regional and global effects (Rybicka, 1996). Air pollution from operational and abandoned coal mines is mainly due to the emissions of particulate matter, and gases such as methane (CH_4), sulphur dioxide (SO_2), hydrogen sulphide (H_2S) and oxides of nitrogen (NO_x) (Zhengfu et al., 2010; Munnick, 2010; Mangena and Brent, 2006). According to Aneja et al. (2012), surface mines generate air pollution, primarily particulate matter, through blasting, wind erosion of exposed areas, and handling of coal at the mines, during transportation and at processing plants. In South Africa, spontaneous combustion is a specific problem where open-cast mining meets old underground board and pillar mine workings (SACRM, 2011). The percolation of air through the coal results in a measurable rise in temperature. As the temperature of the coal rises, the rate of coal oxidation increases, causing self-heating and if conditions are favourable, spontaneous combustion occurs (Pone et al., 2007). The susceptibility of coal to self-heating is dependent on the temperature, rank, amount of surface area exposed, and moisture and pyrite content. Bell et al. (2001) reported that the coal of an abandoned mine in Witbank Coalfield has been undergoing spontaneous combustion for over 50 years. It was also found that land subsidence caused crown holes and tension cracks which allowed free passage of air into the mine. As heat was not readily conducted away from hot spots, this created an ideal situation for spontaneous combustion of the coal (Bell et al., 2001).

A study by Pone et al. (2007) confirmed that gases released from vents in the Witbank and Sasolburg coalfields through spontaneous combustion consist of a complex mixture of hydrocarbons, halocarbons and greenhouse gases, which are associated with negative effects on the environment and on human health. Similar findings were reported by Dlamini (2007) in an investigation of atmospheric pollution resulting from an open-cast coal mine located in Mpumalanga. This investigation revealed that sulphur dioxide (SO_2), carbon monoxide (CO), oxides of nitrogen (NO), and hydrogen sulphide (H_2S) were emitted by spontaneous combustion of this coal (Dlamini, 2007). Concerns have also been expressed regarding the possible release of toxic metals, such as arsenic and mercury, during spontaneous combustion (Munnick, 2010), although there appears to be little quantitative data to support this. In

accordance with a report by the Centre for Environmental Rights (CER, 2016a), and the DEA (2011) HPA Baseline Report, coal mining(including coal fired power stations) is by far the largest contributor of gaseous emissions on the Highveld, accounting for 89% of particulate matter (PM), 90% oxides of nitrogen (NO_x) and 99% of sulphur dioxide (SO₂) releases. It is for this reason that the Minister of Environmental Affairs and Tourism declared the Highveld region a priority area in 2007 (CER, 2016a; CER, 2016b).

Air pollution has also been associated with spontaneous combustion of coal waste dumps, particularly in the case of old inactive mines, in KwaZulu-Natal (KZ-N) and Mpumalanga (Witbank, Sasolburg, Highveld, and Klipriver coalfields) (DME, 2001; Bell et al., 2001; Pone et al., 2007). Also of environmental concern are the solid by-products of spontaneous combustion, left on the surfaces of the coal deposits. According to Pone et al. (2007), these are mostly oxidised sulphur and sulphur-bearing minerals, which may be leached into the surrounding environment on exposure to water. It is impossible to assess and quantify all potential emissions and damage induced by coal but it is known that global warming can be attributed to pollution from coal mining as methane (CH₄) and carbon dioxide (CO₂) contribute significantly to the greenhouse effect (Greenpeace, 2008). The air pollution caused through spontaneous emissions of particulate matter and toxic gases including carbon dioxide (CO₂) contribute to climate change and may cause acid rain which in turn causes soil acidification and formation of AMD, thereby polluting water sources. According to Greenpeace (2008), even in the face of climate change, many countries still plan to build new coal mines, and if the plans materialise, carbon dioxide (CO₂) emissions from coal will increase by 60 %.

Apart from spontaneous combustion and methane (CH₄) leaks, air pollution also occurs as a result of dust fall-out. According to the DEA (2011), the Highveld region contributes about 90% of South Africa's emissions of dust. Significant amounts of dust are emitted during surface mining operations and associated operations (Figure 2-3) including drilling, blasting, and transportation of coal and equipment (Zhengfu et al., 2010; WCI, 2009; Rout et al., 2014; Hota and Behera, 2015). According to Rout et al. (2014), 80.2% of total dust emissions are from the transport roads of mines. Screening is the next largest source of dust emission (8.1%) followed by overburden removal (2.8%), top soil handling (2.6%), coal extraction (2.2%), drilling and blasting (1.3%), and coal handling or stockpiling (1.1%) (Rout et al., 2014).



Figure 2-3: Dust emissions during surface operations and transportation of coal (mongoliaeconomy.blogspot.com, 2017; www.smh.com.au, 2017)

Coal dust may contain high levels of particulate matter and traces of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium (Aneja et al., 2012). The presence of these elements in the dust from surface mining was confirmed in a study by Aneja et al. (2012) to determine the environmental exposure of the residents of a community in Southwest Virginia to respirable concentration of dust generated by hauling coal from surface coal mining operations. Aneja et al. (2012) further noted that exposure to dust particulate matter (PM) is correlated with cardiovascular and respiratory mortality. In another study aimed at collecting, characterising and determining the mineralogical composition of airborne particles near the power plant and open-cast coal mine in Kolubara Basin, Serbia, Cvetkovic et al. (2012) found that dust contained coal particles and mineral grains of quartz, feldspar, clays, gypsum, dolomite, calcite, micas, chlorite and hematite.

- ***Water Consumption***

South Africa is a relatively water scarce country, the 30th driest in the world, and lacks sufficient natural lakes, resulting in a high dependence on dams for water supply (De Klerk, 2016; CER, 2016a). Coal mining has a significant impact on local water resources through high water consumption and pollution as it requires excessive amounts of clean water in order

to operate (Bester and Vermeulen, 2010; Howard, 2016). Historically, water scarcity has been a cause of conflict between the mining and agricultural industry, and as such coal mining is adding to the already existing water crisis (Bench Marks Foundation and Bread for All, 2015; Howard, 2016). According to the WWF (2011), current planning for coal mining does not take account of important water resources. In South Africa, particularly, the impact on water resources as a result of coal mining and coal-fired power stations has been exacerbated by the backlogs in awarding water-use licenses and coal mining and prospecting rights in relation to ecologically sensitive areas. The backlogs and irresponsible awarding of licences have resulted in mining operations taking place unchecked and without the valid licences (Howard, 2016). Most mining takes place in arid regions and in the relatively high water-yield areas of the grasslands. This puts pressure on water users, presenting a need to redistribute and reallocate water resources. Water consumption occurs mainly in underground mining, coal preparation (or beneficiation) and dust suppression. South African coal preparation plants are reportedly using half a tonne of water per tonne of high grade coal washed (Mangena and Brent, 2006).

Consumption may vary according to the operations: low-grade coal preparation plants involving simple crushing and screening use less water, whilst plants involved in dust suppression activities and in irrigation of reclaimed land and deposition of large amounts of low-density slurry consume larger quantities. In surface mining operations, dust control alone consumes around 22.8 litres of water per ton of coal produced (Mavis, 2003). Coal mining operations also impact on ecological infrastructure, including water resources, resulting in a decrease in ecosystems services provided by these systems (De Klerk, 2016). Aquifers and wetlands can be drained decreasing the amount of water available to local communities for consumption and agriculture—communities are then forced to rely on alternative water sources such as storage tanks, or to collect water from other distant sources which may be difficult to access and/or unreliable (CER, 2016a). The mining operations can also further cause significant disruptions to the surrounding groundwater tables and hydrogeological pathways as a result of pumping excess water from underground and surface workings.

- ***Water Quality***

In South Africa, it is, however, the impact of coal mining on water quality that is considered to be the industry's most severe environmental impact (McCarthy and Pretorius, 2009; Reddick, 2006). To facilitate the management of water resources, South Africa is divided into

nine catchment-based Water Management Areas (WMAs), namely: the Limpopo, Olifants, Inkomati-Usuthu, Vaal, Orange, Pongola -Mtamvuna, Mzimvubu-Tsitsikama, Breede Gouritz and Berg Olifants WMAs (DWA, 2013). The Water Research Commission (WRC) published a Mine Water Atlas for the purposes of mapping the un-mitigated threat of mining to water resources across South Africa. Based on the findings of the atlas, South Africa's surface and groundwater resources show pronounced regional differences and changes in water quality. This is influenced by wastewater discharges and land-based activities, with mining (acids and salts) amongst the major impacting sources (WRC, 2017). Of the nine WMAs, coal mining is reported to present significant (medium to high) risks to water quality, due to AMD potential of the Karoo coalfields, and potentially toxic trace elements within the Limpopo, Olifants, Inkomati-Usuthu, Vaal, Pongola -Mtamvuna, and Mzimvubu-Tsitsikama WMAs. According to Tiwary (2001), the sources of water pollution in coal mining areas are:

- Drainage from mining sites including AMD and mine water;
- Sediment runoff from mining sites;
- Oil and fuel/workshop effluents;
- Leaching of pollutants from waste dumps; and
- Sewage from sites.

As previously discussed, mining has a significant impact on land surfaces. Disturbed land surfaces are prone to erosion which in turn may increase sediment loading (Mangena and Brent, 2006). This is more likely to occur in tailings piles, discard dumps, roadways, product stockpiles, and other land areas disturbed during, and shortly after, the construction phase of a mining operation (Mangena and Brent, 2006). Drainage and mine subsidence have an immediate effect on the water environment due to the connection of underground water bodies to the mined space through fractured overburden (Zhengfu et al., 2010).

The most significant water quality concern relating to the coal industry, both locally and globally, is that of Acid Mine Drainage (AMD), also referred to as Acid Rock Drainage (ARD). AMD is produced from the oxidation of sulphide-bearing minerals, particularly pyrite (FeS_2), which occur in most coal and certain polymetallic mineral deposits. Every mine is unique in terms of its generation potential (Zhengfu et al., 2010, Akcil and Koldas, 2006). The oxidation of pyrite (FeS_2) as a result of exposure to oxygen, water and naturally occurring bacteria results in the formation of acid, sulphate ions, and soluble metal cations (Vyawahre and Rai, 2016). Although the process of AMD formation occurs naturally, mining

activities accelerate its generation by increasing the exposure of sulphide minerals to air, water and microorganisms (Akcil and Koldas, 2006). The nature and size of the impact varies with environmental conditions and from site to site, depending on local conditions, geomorphology, climate, and the extent and distribution of the generating deposits (McCarthy, 2011; Simate and Ndlovu, 2014).

Tiwary (2001) and McCarthy (2011) describe the generation of AMD from underground and open-cast coal mines as different processes. On the one hand, underground mining results in collapse of the overlying rock, and when mining terminates, the voids in the fractured rock fill with water and decanting occurs from the lowest opening. The groundwater infiltrates into the mine and becomes acidic as a result of its reaction with pyrite (FeS_2) in the unmined coal and host rock. The acidification of water increases the solubility, mobility and bio-availability of metals, often raising the concentration of these to unacceptable or toxic levels (WWF, 2011). On the other hand, open-cast mining involves blasting and removal of the rocks overlying the coal layer which is removed completely. The ground water, rainwater and associated run off may be acidic in nature, but when it penetrates through the soil backfill covering the fragmented rock, the backfill becomes acidified by pyrite (FeS_2) in the backfill material and eventually decants on the surface (Tiwary, 2001; McCarthy, 2011). AMD has a very low pH value, as low as 2.5 (Oelofse, 2008), and can be easily identified by its yellow-brown colour, as shown in Figure 2-4. The metals known to respond to a low pH from AMD processes are aluminium, beryllium, cadmium, copper, cobalt, chromium, mercury, manganese, nickel, lead, and vanadium (WWF, 2011). *“The drop in pH leads to the conversion of all dissolved carbonates and bicarbonates into carbonic acid, which dissociates to carbon dioxide and water. This process nullifies the bicarbonate buffer system of water, and then water no longer has a natural control system to resist pH changes (WWF, 2011)”*.



Figure 2-4: AMD examples from an old metalliferous mine and an old colliery, South Africa (Akcil and Koldas, 2006).

Metal-rich AMD renders water sources undrinkable for humans and too toxic for use in irrigation and agriculture. This further presents adverse effects upon aquatic species, wildlife, and surrounding vegetation, and corrodes infrastructure (Tiwary, 2001; Vermeulen et al. 2007, Simate and Ndlovu, 2014). This became evident when water from local communities supplied from the Boesmanspruit Dam in Carolina was deemed unfit for cooking, drinking, irrigation and washing for seven months, after a storm caused a run-off at coal washing and loading facilities into the dam (CER, 2016b; McCarthy and Humphries, 2013). The water in the dam turned dark green, rendering it toxic and unfit for human consumption, and fish in the dam started dying. A chemical analysis confirmed that the pH level of the water had dropped to 3.7, with elevated levels of iron, aluminium, manganese and sulphate (CER, 2016b; McCarthy and Humphries, 2013).

AMD has become a serious environmental concern for the long-term sustainability of the country's fresh water supply (McCarthy and Humphries, 2013). The deterioration in the quality of water has led to the decimation of vegetation in some areas and the eradication of aquatic flora and fauna in nearby streams (Bell et al., 2001). A 2011 study by the DWA (now DWS) found coal mining around the Wilge, Bronkhorstspuit, Klein Olifants and Olifants Rivers to be the main contributor to poor water quality and in-stream conditions (CER, 2016b). *"In the Olifants catchment, coal mining has contaminated rivers and streams to the extent that it cannot be used in the coal-fired power stations. Eskom's water either needs to be treated – costing money and more energy – or it must be supplied from another river system that has not been polluted by mining"* (WWF, 2011). Also as a result of mining, irrigation return flows, and wastewater discharges, it is further noted in the Mine Water Atlas

that: *“the upper Olifants catchment is predominantly in an unacceptable state for the main stem Olifants River and many of the tributaries, but improves to a tolerable status at Loskop Dam. The salinity in the middle Olifants River falls in a tolerable range, and improves to an acceptable state in the Lower Olifants within the Kruger National Park. Many of the tributaries, including the Elands River, Wilge River, Steelpoort and the Ga-Selati, are in a good to acceptable status in the upper reaches of the catchments but deteriorate to unacceptable salinity ranges in the lower reaches before confluence with the Olifants River”* (WRC, 2017). Vermeulen et al. (2007) state that AMD is virtually impossible to reverse with existing technology, very complex to control and treat, and once started, can cost millions to treat. Because most treatment technologies are either inadequate or expensive, AMD is usually left untreated to cause long term impairment to the environment thereby threatening human health, plant life and aquatic life (Akcil and Koldas, 2006 ; Simate and Ndlovu, 2014).

2.1.2. Eco-System Health Effects

The impacts on land, water and air, as outlined above, pose a significant threat to ecosystems. Landscape change affects the structure and function of the ecosystem through waste dumping, establishment of high shaft towers, large scale surface scarring, and destruction of land resources, fragmentation and desertification (Zhengfu et al., 2010). This may further result in destruction of national critical resource areas including Fresh Water Ecosystem Priority Areas (FEPAs) and Critical Biodiversity Areas (CBAs). As outlined in the CER (2016b) report, the 2013 Mining and Biodiversity Guideline describes impacts from mining on biodiversity as follows:

- The loss and/or degradation or conversion of land, marine and other aquatic habitats and associated loss of species;
- Significant alteration of ecological processes, sometimes irreversibly;
- Pollution (including noise and light pollution) and migration of pollutants in air, soils, surface water, groundwater or the ocean;
- Introduction of invasive alien species;
- Changes in demand for, or consumption of, natural resources.

AMD, in particular, may pose significant impacts on the environment, including destruction of land resources and water sources in which wildlife and aquatic life thrive. Contamination of soils by AMD presents adverse effects for plant growth and development (Sarma, 2005;

Simate and Ndlovu, 2014). Plants experience oxidative stress upon exposure to heavy metals, leading to cellular damage and disturbance of cellular ionic homeostasis, disrupting the physiology and morphology of plants (Simate and Ndlovu, 2014). Most plants cannot tolerate low pH water because the high hydrogen content causes inactivation of enzymes, restricting respiration and root uptake of mineral salts and water (Bell et al., 2010). In the Mpumalanga Province, South Africa, pollution from coal mining is affecting Chrissiesmeer, South Africa's largest wetland, which covers 6 200 hectares and includes the Tevrede wetland which feeds into the Vaal, iMpuluse/Usuthu, Olifants and Komati Rivers that supply many parts of the country (Biyase, 2015; CER, 2016b). Chrissiesmeer was declared a protected environment by the DMR in 2012 (CER, 2016b). It is also a declared threatened ecosystem under the National Environmental Management Biodiversity Act (NEMBA), a Fresh Water Ecosystem Priority Area and a Critical Biodiversity Area.

Aquatic organisms accumulate heavy metals directly from contaminated water and indirectly via the food chain (Simate and Ndlovu, 2014; Jennings et al., 2008). The toxicity and acidity of AMD contaminated water have been found to result in severe oxidative stress, which impairs the osmotic balance of fish by interfering with the uptake of salts through the gills (Chadwick, et al., 2013; Simate and Ndlovu, 2014). Acute exposure to the metals may result in death whilst chronic exposure may result in mortality or stunted growth, reduced growth, reduced reproduction, deformities or lesions (Simate and Ndlovu, 2014). The primary cause of death in acid water is the loss of sodium ions from the blood: *“less availability of oxygen to the cells and tissue leads to anoxia and death as acid water increases the permeability of fish gills to water adversely affecting the gills function”* (Vyawahre and Rai, 2016). Jennings et al. (2008) quote some studies that have been undertaken on the distribution of fish in Pennsylvanian streams affected by acid mine drainage. The studies have revealed that whilst some species showed tolerance at pH 5.5 and below, most fish were severely impacted at pH 4.5 to 5.5. A complete loss of fish was observed in 90% of streams with waters of pH 4.5 and total acidity of 15 mg/L (Jennings et al., 2008).

Andersen et al. (2014) noted that the greatest potential for negative impacts on biodiversity is not from individual mines, but from the cumulative impacts of extensive development in highly prospective regions or where diffuse development takes place over large regions. Given this cumulative effect, mining can potentially affect biodiversity regionally through a combination of the scale of exploration activity, the mine sites themselves and, importantly,

the roads, towns, pipelines, water supplies and ports required to service them (Andersen et al. 2014).

2.1.3 Human Health Effects

Coal mining and coal-fired power stations have been shown to cause serious health and social harm to people living in surrounding communities (Colagiuri and Morrice, 2015). The health challenges faced within the coal mining industry are HIV/AIDS, tuberculosis and other communicable diseases, silicosis, and noise-induced hearing loss (SACRM, 2011). The effects of environmental pollution come as externalities and are inflicted upon the society (Hota and Behera, 2015). In a study based on household-level data collected from four mining (polluted) villages and two control (non-polluted) villages, Hota and Behera (2015) showed that people residing in coal mining communities are at an increased risk of developing chronic diseases with high mortality rates, including heart and lung disease, cancer, hypertension and kidney disease. Similarly, reports by ActionAid (2014) claim that studies of the health effects in coal mining communities have found that members of coal mining communities have a 70% greater risk of developing kidney disease, a 64% greater risk of developing chronic obstructive pulmonary disease (COPD) such as emphysema and are 30% more likely to report high blood pressure/hypertension. One particular study that proved this to be true is by Colagiuri et al. (2012). Evidence in Colagiuri et al. (2012) revealed that adults in coal mining communities had higher rates of mortality from lung cancer and chronic heart, respiratory; kidney diseases and higher rates of cardiopulmonary disease, chronic obstructive pulmonary disease (COPD) and other lung diseases; hypertension, heart attack and stroke, and asthma. Children were found to have increased respiratory symptoms, high blood levels of heavy metals such as lead and cadmium, and birth defects including neural tube defects (Colagiuri et al., 2012).

- ***Exposure to Environmental Air Pollutants***

As discussed above, air pollution from coal mining is mainly due to emissions of particulate matter, gases, and toxic compounds from spontaneous combustion and dust fall-out. The inhalation of contaminated dust (consisting of particulate matter and traces of heavy metals) from coal mining and associated operations as outlined above has been associated with serious health problems (ActionAid, 2014), particularly the spectrum of diseases termed “coal mine dust lung disease” (CMDLD) (Laney and Weissman, 2014). The common occupational lung diseases are Coal Workers’ Pneumoconiosis (CWP) and silicosis. CWP or

Black Lung disease is defined by coal-dust induced lesions in the gas exchange regions of the lung (Finkelman, 2004; ActionAid, 2014). The disease, which is directly caused by inhaling coal dust, progressively builds up in the lungs until it can no longer be removed by the body, leading to swelling, fibrosis (scarring of the lungs) and, in the worst cases, death (Action Aid, 2014).

Environmental air pollution as a result of coal mining can lead to various respiratory health problems, including acute respiratory illness and chronic bronchitis, with a possibility of premature death (Hota and Behera, 2015; Laney and Weissman, 2014). A study by Rout et al. (2014) to establish the quantum of atmospheric dust fall and its mineral and morphological characteristics in the Jharia coal mining area found that the major minerals in coal dusts were quartz (SiO_2), pyrite(FeS_2), albite and magnesiohornblende (Rout et al., 2014). Another Chinese study found nano quartz particles in a bituminous coal seam and in the lungs of rural residents who were burning coal in their homes (Dai et al., 2008). Quartz (SiO_2) is a form of silicate which when inhaled may cause Silicosis. Silicosis is a respiratory disease characterised by inflammation and scarring in forms of nodular lesions in the upper lobes of the lungs (Chen et al., 2005). Another study by Cohn et al (2006) on the role of pyrite in formation of hydroxyl radicals in coal and the possible implications for human health confirmed the presence of pyrite in coals and concluded that the prevalence of CWP can be correlated to the amount of pyrite (FeS_2) in the coals.

Studies in Britain have also linked coal mining to increased incidences of asthma in the surrounding communities (Hendryx, 2015). However, whilst Hendryx (2015) makes a connection of coal mining and health, Moffat and Mulloli (2003) found no link between children's asthma and its increase in prevalence in a similar study conducted in the United Kingdom. This study explored the health and environmental concerns of parents living close to open-cast mines in the UK. Uncertainty characterised the concerns of the parents, who anticipated health concerns at the planning stage. The findings, however, also showed an increase in dust and higher rates of GP consultations for respiratory conditions (Moffat and Mulloli, 2003).

- ***Ingestion of Contaminated Water and Crops***

AMD is mainly responsible for water pollution; it contains toxic, dissolved heavy metal pollutants which are dangerous to both human and animal health (Vyawahre and Rai, 2016).

As outlined above, water that has come into contact with AMD is undrinkable for humans and too toxic for use in irrigation and agriculture (Greenpeace, 2008). The acidic nature of AMD (Oelofse, 2008) dissolves heavy metals such as copper, lead and mercury that may end up in ground and surface waters (Zhengfu et al., 2010) which, as a result of this acidity are unsuitable for the use of animals, plants, mankind and aquatic life (Vyawahre and Rai, 2016). The heavy metals persist in natural ecosystems for an extended period and accumulate in successive levels of the biological chain, thereby causing acute and chronic diseases (Simate and Ndlovu, 2014). As outlined above, AMD not only affects water quality but may also affect soil fertility and its productivity and further impair plant and crop quality. When humans consume the contaminated water and crops, the toxicity of the metals contained in AMD will disrupt metabolic functions (Hendryx, 2015; Bench Marks Foundation and Bread for All, 2015; Hota and Behera, 2015; Simate and Ndlovu, 2014). The heavy metals accumulate in vital organs and glands such as the heart, liver, kidney, and brain impairing their function and further inhibiting absorption of necessary nutrients in the body (Hendryx, 2015; Bench Marks Foundation and Bread for All, 2015; Hota and Behera, 2015; Simate and Ndlovu, 2014).

- ***Direct Combustion of Coal Wastes***

Coal contains toxic trace elements which have known adverse health effects at high levels of exposure (ACARP, 2006). These elements are arsenic, boron, cadmium, chromium, fluorine, mercury, molybdenum, lead and selenium. The compounds of these elements are mostly volatile and may be released to the atmosphere through gaseous emissions and in stack particulates (ACARP, 2006). Residential coal combustion produces these gaseous emissions consisting of volatile elements. Health-related problems that can be encountered from the use of coal are fluorosis, arsenism and selenosis (Finkelman et al., 2002; Zheng et al., 1999). The elements may also form efflorescent minerals on the surface of the ground which may be leached by rainwater and washed into local water bodies presenting other potential routes of exposure. Zheng et al. (1999) reported that in southern west China, 15 million people suffered from fluorosis, more than 3000 had arsenism and 477 people had endemic selenium intoxication due to the use of high fluorine, arsenic and selenium coal in unvented ovens. The impact from the exposure to the elements is aggravated by the burning of coal within poorly ventilated households, especially in informal settlements and rural villages (Balmer, 2007). South Africa was reported in 2006 to be second to China in mercury emissions as a result of

coal combustion, contributing more than 10% of global mercury emissions (ActionAid, 2014).

In South Africa, informal mining and the use of coal for residential purposes appears to be shaping the way of life for people living in proximity to Coronation coal mines in Mpumalanga Province (ActionAid, 2014). According to ActionAid (2014), the coal waste piles at Likazi informal settlement near Coronation are being mined by informal miners, including children, for their own energy needs and as a form of income (see in Figure 2-5). This activity entails the use of low-grade coal for domestic purposes at an unregulated level which in turn may present health problems. Burning the coals volatilizes the toxic elements thereby exposing the users and the rest of the local population to the toxic elements. People who have been exposed to these elements exhibit serious health problems which may be very severe—leading to death, widespread—affecting many millions of people, and complex — requiring a multi-disciplinary research approach (Finkelman et al., 2002). In 2014, the CER conducted a survey of mining-affected communities in Middleburg and Hendrina in the Mpumalanga Province (CER, 2016b). The results of the survey revealed that 58% of the participants said that they were suffering from poor health: many of the respondents suffered from severe coughing, asthma or other respiratory problems, while only 19% smoked; 64% were suffering from nausea, migraines or headaches. Only 37% said they were sleeping well.



Figure 2-5: A woman standing in a sinkhole while digging for coal and a man firing up an imbawula that will be used at home for heat and cooking (ActionAid, 2014).

Balmer (2007) reports that studies conducted in Gauteng found household coal burning to be the largest contributor to local air pollution. One study revealed that domestic coal burning accounted for 65%, whilst electricity generation contributed 5 % and commercial organisations 30% (Balmer, 2007). Not only does air pollution cause respiratory infectious but also other problems such as suffocation or carbon monoxide (CO) poisoning caused by poor ventilation in houses; irritation to eyes, noses and throats; as well as aggravation of illnesses such as asthma, TB and HIV/Aids (Balmer, 2007). Further, the use of coal causes smelly clothes, damage to furniture and curtains, and ultimately undermines self-esteem and self-worth (Balmer, 2007). Table 2-1 below presents the potential health risks which are posed by mercury, arsenic, fluorine and selenium from residential coal use. A number of diseases may be linked to poisoning by these volatile elements which may be prevented and treated. Health problems caused by fluorine are far more extensive than the rest and may lead to severe bone deformation in malnourished children. Selenium has fewer symptoms and, whilst mercury poisoning may be occurring, there is no direct evidence of health problems linking to mercury (Finkelman et al., 2002; Finkelman, 2004).

Table 2-1: Possible health impacts of trace elements from coal (Zheng, 1999)

Element	Health Impacts
Fluorine	<i>Fluorosis</i> : mottling of tooth enamel, osteosclerosis, limited movement of joints, knock-knees, bow legs, spinal curvature
Selenium	<i>Selos</i> : Hair and nail loss, skin discoloration
Arsenic	<i>Arsenism</i> : <ul style="list-style-type: none"> • pigmentary skin changes: flushed appearance, • hyperkeratosis: freckles, scaly lesions on the skin • Bowen's disease: dark, horny lesions of the skin • Squamous cell carcinoma
Mercury	Hair loss, loss of vision

2.1.3 Impact on Community Livelihoods

Generally, a livelihood is a means of gaining a living and comprises the capabilities, assets and activities required for a means of living (Mishra, 2009). Mineral resources may play a critical role in fostering economic growth including creation of employment opportunities but may also have negative impacts on local communities' livelihoods (Hota and Behera, 2015). Mining generally takes place in rural areas where most people of low economic class reside. New mining projects have had many significant impacts on the livelihoods and quality of life of the people in these areas, creating new poverty.

In South Africa, coal mining is reported to have had significant effects on the quality of life and livelihoods of local communities in the central basin. (ActionAid, 2014; CER, 2016b; Bench Marks Foundation, 2014). In 2014, the Bench Marks Foundation released a report, *Policy Gap 9 on South African Coal Mining: Corporate Grievance Mechanisms, Community Engagement Concerns and Mining Impacts* (Bench Marks Foundation, 2014) which focused on communities near mines in the Nkangala District, including Witbank (eMalahleni) and Middelburg (Steve Tshwete), in South Africa, and on two mining corporations, Anglo American Corporation and BHP Billiton. According to the report, coal mining is seriously impacting the surrounding communities as a result of child labour, environmental pollution and reduced access to agricultural land and water. A study by the Bureau for Food and Agricultural Policy (van der Burgh, 2012) also found coal mining to be linked to increased food production costs, livestock and security costs, labour sustainability, and competition for skilled labourers.

Further abroad, a study on the positive and negative impacts that mining has on the livelihoods of the local communities in the Ib valley coalfield in Orissa revealed that, although the economy and standard of living of local communities had risen considerably with the advent of coal mines, this benefit was at the cost of their environment (Mishra, 2009). The study by Mishra (2009) showed that people are displaced from their land and lose their homes and agricultural-and forest-based livelihoods; the natural environment is degraded; and there is air and water pollution, and an influx of skilled labour migrants, creating tensions between people and outsiders (Mishra, 2009). Another study done in the Ib valley by Hota and Behera (2015) assessed the cost of coal mining on agriculture and human health in western Odisha and found the cost incurred by the local communities, particularly in

terms of loss of agricultural production and wage income, and the increase in medical expenses, to be substantial.

Apart from health, one of the biggest impacts of coal mining on human well-being appears to be related to livestock and crop production. As discussed in Sections 2.1.1 and 2.2.2, coal mining and processing can have a significant effect on the availability and quality of natural resources. This, in turn, has an adverse effect on the crop and livestock farming due to reduced access to agricultural land, and a decline in soil productivity and crop quality, as well as livestock fertility. The impact on access to arable land is of particular relevance to the coal mining area of Mpumalanga in South Africa. A study conducted for the Maize Trust by the Bureau for Food and Agricultural Policy (van der Burgh, 2012) indicated that 12 % of the country's total high-arable land has been transformed and 13.6% is under prospecting by the mines in Mpumalanga (Figure 2-6). These areas included 326 000 ha of cultivated land to be taken by current mines and 439 000 ha which had prospecting taking place on them, amounting to 993 301 ha loss of cultivated land (van der Burgh, 2012). In Figure 2-6, the green-shaded areas indicate areas of high to low cultivation potential, whilst the grey shaded areas are those currently covered by mining, with the pink shaded areas indicating areas under prospecting.

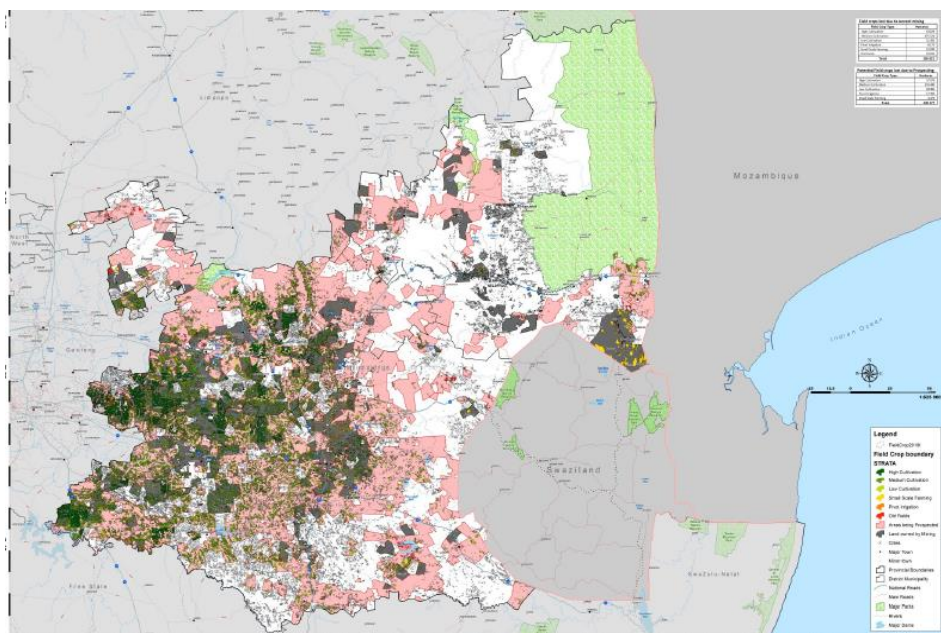


Figure 2-6: Field crops lost due to mining and prospecting in Mpumalanga —the green shaded areas are of high to low cultivation potential, the grey-shaded areas are those currently covered by mining, and the pink-shaded areas are under prospecting (van der Burgh, 2012)

According to the CER (2016b), the 2014 National Policy on Food and Nutrition Security also found mining to have unfavourable effects on agriculture: in the period between 1994 and 2009, the overall area under food production declined by 30%. The CER (2016b) further reports that the Department of Agriculture, Forestry and Fisheries confirmed that South Africa has a limited supply of agricultural land making reference to a spatial analysis which found the loss of arable agricultural land to non-agricultural uses to be equal to the size of the Kruger National Park. Even in cases where land is not occupied, or becomes available once mining has ceased, the impacts of mining activities on land stability and soil fertility can be so severe that farming activities cannot be sustained (CER, 2016b; GroundUp and Davies, 2014; Mangena and Brent, 2006).

The impacts of mining on agriculture and, ultimately, food security can also be indirect. For example, the Bench Marks Foundation study in 2014 (Bench Marks Foundation, 2014) also found that many small farmers along the roads to Kendall and Ogies in the Mpumalanga coal mining region of South Africa have switched from farming and converted their land into truck stops to service the collieries in the area. Farming exports have been affected as farmers have lost European clients due to the effects of poor-quality irrigation water on crops (Bench Marks Foundation, 2014). Heavy metal bearing Acid Mine Drainage (AMD) is particularly problematic. As discussed in Section 2.1.2, pollution of land and water resources with AMD creates unfavorable habitat for both plant and aquatic life (Vyawahre and Rai, 2016) such that agricultural production and aquaculture have been found to have reduced due to mining activities. In accordance with this study, the environmental pollution from mining operations has also affected livestock fertility and milk production (Bench Marks Foundation, 2014). Similarly to humans, water that has come into contact with AMD is unsuitable as drinking water for animals (Greenpeace, 2008; Simate and Ndlovu, 2014). AMD has a low acidic pH which dissolves toxic heavy metals such as copper, lead and mercury that may end up in ground and surface waters (Zhengfu et al., 2010; Oelofse, 2008). When animals consume the contaminated water and plants, the acidity and toxicity of the heavy metals contained in the AMD disrupt metabolic functions: the heavy metals accumulate in vital organs and glands such as the heart, liver, kidney, and brain where it impairing their function and further inhibiting absorption of necessary nutrients in the body (Simate and Ndlovu, 2014). In their study based on household-level data collected from four mining (polluted) villages and two control (non-polluted) villages in the Ida Valley, Hota and Behera (2015) found that pollution

of land and water by AMD arising from coal mining resulted in a loss in livelihood from both fishing and farming.

The presence of high levels of suspended particulate matter is also a major problem for agriculture and it is observed that air pollution affects agriculture in numerous ways (Hota and Behera, 2015). The high levels of particulate matter and of traces of elements contained in coal dust have the potential to reduce both the yield and the nutritional quality of crop plants when the coal dust falls onto the plants, affecting their nutrients, photosynthesis and production (Aneja et al., 2012). Coal mine dust is reported to have an immense effect on crops in the Mpumalanga area (van der Burgh, 2012).

As discussed in Section 2.2, the impacts of mining on agricultural activities have frequently been at the centre of conflict between mining companies and local communities.

2.2 A Summary of Historical and Current Social Conflicts and Incidents

Whilst mining companies emphasise the local socio-economic benefits of mining, such as job creation and infrastructure development, non-profit organisations claim that the costs of mining are borne by the public and the environment rather than by the companies whose activities occasion them (CER, 2016a; CER, 2016b). Various reports (including the policy gap series by the Bench Marks Foundation, the CER report on the poor governance of mining, and the Groundwork 2016 report highlight the issues associated with coal mining and how these have drastically impacted on local communities. Table 2-2 is a summary of some of the civil society organisations (CSOs) that are working to promote human rights in communities affected by mining operations across the world and in South Africa. CSOs are *“voluntary organizations with governance and direction coming from citizens or constituency members, without significant government-controlled participation or representation, and include community-based organizations and village associations, environmental groups, women’s rights groups, farmers’ associations, faith-based organizations, labour unions, co-operatives, professional associations, chambers of commerce, independent research institutes and the not-for-profit media.”* (<http://www.cn.undp.org>). A study by the ICMM (2015) revealed that mining-related conflict between communities and companies had increased over the period 2012-2013, with environmental and economic grievances dominating. A study by Davis and Franks (2014) confirmed environmental pollution to be the most common cause of mine-community conflict globally, followed by access to resources and distribution of

benefits. Mining company-community conflicts are mainly due to the impacts of mining activities on water, air quality, biodiversity, livelihoods, and ecological infrastructure, and on the health and wellbeing of communities (CER, 2016b). Researchers have attributed this rise to the asymmetries of knowledge, power and control between corporate and community stakeholders, stipulating that consultation meetings are largely symbolic and are simply a routine duty which soothes the consciences of government officials when mining and water use licences are issued (ActionAid, 2014).

Australia has seen an increase in tensions and conflicts between agricultural communities and mining sectors in the opening decades of the 21st century (Duus, 2013). These conflicts are mainly attributed to concerns about water, food security, health, community impacts, local and national economic imbalances, property rights and climate change (Duus, 2013). In particular, local communities and farmers are concerned about the impact of coal mining on surface water quality, livestock health, and loss of fertile cropping land and food production potential. These concerns have led to the rejection of a number of applications to expand and develop new coal mines over the period 2010-2012. For example, applications to expand the open cut Bickham mine in NSW in 2010, and to develop a new coal mine in the vicinity of the Margaret River in July 2012, were rejected by the New South Wales (NWS) government due to concerns over environmental and, in particular, water impacts (Duus, 2013). Whilst these official responses have been substantial, the impacts from coal mining have not changed but are now accelerating and occurring on a greater scale (Duus, 2013).

In South Africa, environmental pollution from coal mining has been well observed and a number of case studies have shown a potentially significant link between environmental degradation, poor health, and livelihood destruction. This section presents a South African scenario of historical and current conflicts and incidents associated with the impacts from coal mining.

Table 2-2: Organisations that promote human rights in communities affected by mining operations

Organisation Name	Location	Objective(s)	Activities
The Bench Marks Foundation	Johannesburg, South Africa	To monitor multinational corporations operating in Southern Africa and the rest of the African continent to ensure that they meet minimum social, environmental and economic standards	Advocacy: Research, media campaigns, community organisation and monitoring
ActionAid	South Africa (Johannesburg), Asia, Europe, America	To work against poverty and injustice worldwide.	Human rights advocacy and support: inequality, youth, HIV/AIDS, democratic governance, education, emergency and conflict, climate change
Groundwork	Pietermaritzburg, KwaZulu Natal, South Africa	To improve the quality of life of vulnerable people in South Africa who are most affected by environmental justice	Research, Solidarity and Empowerment campaigns: climate and energy justice, coal, waste, environmental health
Centre for Environmental Rights	Cape Town, South Africa	To help communities and civil society realise their constitutional right to a healthy environment	Legal research, advocacy and litigation
Federation for a Sustainable Environment	Johannesburg, South Africa	To promote environmental and social justice in the mining industry	Advocacy and research
Open Society Foundation	Cape Town South Africa, Asia, Europe, Latin America and the Caribbean, Middle East, United States	To promote extractive sector transparency and accountability	Research and advocacy
Greenpeace International	Africa, America, Europe, Asia and the Pacific	To change attitudes and behaviour, to protect and conserve the environment and to promote peace	Global campaigns against environmental degradation
Earth Justice	San Francisco, USA and International partnerships	To promote a healthy environment: wildlife, communities, healthy climate	Litigation
Earth Life Africa	Johannesburg, Pretoria, Durban, Cape Town and Namibia	To encourage and support individuals, businesses and industries to reduce pollution, minimise waste and protect our natural resources.	Campaigns: AMD, Biodiversity and toxins, renewable energy, nuclear energy, climate change
International Council on Mining and Metals	United Kingdom	To enhance mining industry's social and environmental performance and its contribution to society	Environmental stewardship, role of mining in society, human wellbeing

- ***Limpopo Province***

In the Limpopo Province, South Africa, mine company-community-government conflict has been evident between Coal of Africa Limited (CoAL) and a local community (Prinsloo, 2014). CoAL is an Australian company that explores and develops thermal and coking coal mining projects. Two of its mines, the Vele and Makhado projects, have received strong opposition from community members, NGOs and some government departments. The opposition is in relation to inadequate consultation and the environmental and human rights impacts the mines come with. The concerns resulting in the opposition to the Vele mine were mainly to do with the potential of the mine to consume high amounts of water; ground water pollution, dust pollution from mining transport; and destruction of agricultural and tourism activities and jobs. CoAL unlawfully commenced several activities listed under the NEMA, including the unlawful use of water without the required authorisations, and was fined R9 million and given a directive by DWS to cease all unlawful water use (Bench Marks Foundation and Bread for All, 2015). In 2013, mining was stopped temporarily due to the mine producing low grade coal, although CoAL had still planned to increase the mining area from 102 ha to 502 ha (Bench Marks Foundation and Bread for All, 2015). Although not operational, the Makhado Mine has also received massive opposition from the local Mudimeli community (located just 250 metres from the mine site), local white farmers and eco-tourism businesses. The opposition has called for alternative development opportunities and was against the development of the mine, raising concerns about the inadequate consultation by CoAL, and the potential impacts that the mine has on the water and health of the community. Regardless of the on-going opposition, the mining right was granted by the DMR on May 2015. An appeal was ineffectively filed by the Mudimeli community, the Mudimeli Royal council and the Vhembe Mineral Resources Stakeholders.

- ***KwaZulu Natal Province***

Almost all of the coal mines in KwaZulu Natal closed in the 1990s (Schneider, 2016). In the Vryheid region, all mining and processing operations at the Vaalkrans colliery ceased on May 2016, due to financial issues and water issues following a hectic drought that hit the region for two years. The area around Vryheid has numerous abandoned open-cast mines, which have proven to be a safety hazard to local communities. According to van Wyk (2016), cattle frequently fall into open pits and drown. In an article by van Wyk (2016) titled “*Vryheid has abandoned open-cast mines everywhere*”, posted on Action Voices, a platform used by

community activists to share information, resources and experiences, van Wyk (2016) reports some of the incidences that are underway in the Vryheid region. In this report van Wyk (2016) claims that a young man called Sabelo had six head of cattle but now only has three; the others fell into the unrehabilitated open-cast coal mine and drowned. It is claimed that Mr. Viljoen, the renowned owner of this hole, is said to have abandoned it, even though it would be breaking the law, because he knew that there would be no consequences (van Wyk, 2016). Van Wyk (2016) highlights that *“This is prevalent everywhere where there is coal mining; the mining companies come and go, leaving the community with degraded unsafe land”*. In the same area, residents reported that a child also drowned there, and that mine trucks regularly kill livestock without any consequences or compensation. The mine is reported to be currently under care and maintenance (van Wyk, 2016).

At Somkhele, about 85 km southwest of Richards Bay, lies Petmin’s open-cast coal mine operating as Tendele Mining since 2007. In November 2014, members of the local Mpukonyoni community took to the streets in protest against the mine. The members marched to the mine to submit a memorandum comprising 30 grievances to the CEO of the mine (Jolly, 2014). The grievances centred on the impacts from the mine in relation to contaminated water; health issues from dust-filled air, livestock deaths; and housing cracks from blasting. The memorandum was received and signed by the CEO who assured protesters that a meeting would be held with the community representatives. The community was dependent on the now dried-up local Mfolozi River and a local well, having been severely affected by the water shortage in the country aggravated by the presence of the mine to a point that it was going without water for weeks. According to Mokgalaka (2016) *‘the well, depended upon by the community as a water source is currently being privatised by the local coal mine and fenced off to supply water to wash coal by the mine’*. The community is now dependent on water tanks supplied by the local municipality.

On the 14th of March 2016, another march took to the streets, this time destined for the Mpukonyoni Traditional Council. With the support of scholars from the Centre for Civil Society (CCS) at The University of KwaZulu Natal, the Nomathiya Royal House, and activist organisations including the Mining Affected Communities United in Action, the Mfolozi Communities Environmental Justice Organisation (MCEJO) and the Women affected by Mining, the affected 32 communities expressed their discomfort, discontent and frustration against the coal mine and the local authorities for the alleged disregard for people’s

livelihoods (Ngubane, 2016). Although the march was deemed illegal by the local Mayor, the memorandum was received and signed without comment by the MEC of the Department of Cooperative Governance and Traditional Affairs. Whilst there are complaints about the impacts and risks regarding abandoned and existing coal mines, there is also resistance to a proposed new mine by residents from Fuleni, at Mtubatuba in northern KwaZulu Natal (about 10 km from the Somkhele mine). According to the Environmental Justice Atlas (EJA) (2016), opposition to the proposed Ibutho Coal mine has been going on for two years. The Fuleni community is against the mine mainly due to the possible impacts on the iMfolozi Wilderness area particularly the Hluhluwe Game Reserve, and on livelihoods through crop and livestock farming, water and health. The proposed mine will be on the boundary of the reserve and about 500 metres from the local settlements. Further, the members question the loyalty and leadership morale of the local municipality and Traditional Leadership who appear to be in favour of the mine. In 2014, the Provincial Department of Environmental Affairs denied the mine environmental authorization licence but the mine has already started installing pipes on the sites (Mokgalaka, 2015). In a protest held in April 2016, the Regional Mining Development Environmental Committee was forced by local residents to end its site visits to the proposed mine (EJA, 2016). With the assistance of environmental justice organisations such as Groundwork and Global Environmental Trust, the communities of Somkhele and Fuleni have united with other mine-affected communities from Johannesburg, the Highveld and the Waterberg to exchange information and experiences on the injustices from coal mining (Mokgalaka, 2015; EJA, 2016). The MCJE activists, with researchers from the CCS, are also advocating for the communities. Their advocacy not only relates to the impacts from the coal mines on the local communities but also extends to include the wider climate change issues and those of poor governance and implementation by government.

- ***Mpumalanga Province***

The majority of coal mining activity in South Africa takes place in the central basin located in Mpumalanga Province. In this Province, coal mining is taking precedence over agricultural production, main water sources are increasingly becoming contaminated with AMD, and local residents are re-mining coal for domestic use and to make a living (Biyase, 2015b; CER, 2016a; CER, 2016b; Young, 2015). The conflict of interests between coal mining companies and farmers has become widespread with farmers in and around the mining town complaining that the coal companies are scrambling to mine in the area and their complaints

to government have fallen on deaf ears (Biyase, 2015a). The town of Ermelo is a clear example of the socio-economic effects of coal mining. The farmers around the area complain about water sources that are contaminated. W, the pollution of crops by mine dust exacerbates the situation (Biyase, 2015a). The farmers are in fear of their farming businesses, for the mining companies come promising employment but only employ a few local people while the rest of their workforce comes from their other operations. According to an article published on the Sunday Times by Biyase (2015a), Pierre du Hain, a Belgian farmer who started in 2001 as a supplier for Woolworths, has since suspended farming out of fear that he might lose his farm. When he started farming, he envisioned a profitable and sustainable milk and cheese operation, and had the support from the Department of Trade and Industry (DTI). His plan, as presented to the department; was to establish a successful business and thereafter transfer his skills to the willing but less privileged. His efforts have gone unnoticed as the DTI is no longer in contact with him. He was then left with only the Mpumalanga Protection Group to contest the mining right (Biyase, 2015a). Nonetheless, the DMR continues to accept mining right applications in the Chrissiesmeer area; it recently accepted applications from MA Coal (Pty) Ltd and Blue Moon (Pty) Ltd in 2015. Black Gold Coal Estates also expressed interest in mining near Chrissiesmeer (Biyase, 2015a).

The Imbabala open-cast coal mine located in Ermelo was closed by the DMR in 2011 following environmental and noncompliance offences. The mine operated without a water use licence irrespective of a pre-directive granted by the Department of Water and Sanitation. There were also reports that unlawful underground mining was causing cracks in the houses in nearby communities. The mine currently lies abandoned and unrehabilitated (Biyase, 2015b). The residents of nearby local communities now re-mine the coal dumps left behind. Residents of Wesselton Township make a living by selling to the nearby settlements of Londoloza, Nkanini and Mamaks, which have no electricity. In March 2015, an illegal miner was killed by a rock fall whilst trying to tunnel his way in for coal (Young, 2015). The local residents, including those residing in RDP houses, continue using the coal because electricity is expensive. In addition, as discussed above, the residential use of coal produces volatile elements, exposure to which may present health-related problems (Finkelman et al., 2002; Zheng et al., 1999).

The most significant mine-related incident that resulted in conflict between government and the communities is that of the contamination of the Boesmanspruit Dam in Carolina which left the local Silobela community without water for seven months in 2012. The municipal Boesmanspruit Dam supplies the local communities with drinking water. Following a storm, the communities woke up to acid coming out of their drinking water taps. A chemical analysis of the water confirmed that the pH level had dropped to 3.7, with elevated levels of iron, aluminium, manganese and sulphate. The water in the dam then became toxic and unfit for human consumption; fish started dying as the water turned a dark green color. According to McCarthy and Humphries (2013), the elevated sulphate concentration and low pH in the dam water indicated that the contamination originated from coal mining activities in the catchment. The water remained undrinkable for 7 months and emergency supplies were provided by the local municipality. A violent protest by the community members then erupted. On behalf of the Silobela community and the Federation for a Sustainable Environment, the Legal Resources Centre and Lawyers for Human Rights brought a court order against the Department of Water Affairs, and the local and district municipalities to compel them to provide an adequate water supply (CER, 2016b; McCarthy and Humphries, 2013). The community won the case and the court ordered the Gert Sibande District Municipality to provide temporary potable water within 72 hours and to meaningfully engage with the residents. The municipality did not follow the order and appealed the decision delaying the matter further. The court battle went back and forth until the water supply was restored. Nonetheless, the municipality did not engage the community in addressing its needs; no order was granted against the Minister of Water Affairs and no legal action was taken against the mines operating upstream which had caused the pollution problem.

2.3 Responses to Environmental and Social Impact Concerns

South African legislation requires mining companies to be responsible for their environmental and social footprints in all their mining areas. Focus, often advocated by civil society organisations, has been more on the impacts that come with coal mining than on the efforts that government and mining companies make to ensure compliance with their environmental and social requirements and mandates. In considering the various mitigation options, it is necessary to distinguish between those that are used whilst mines are still operating, and those that will be used after closure. For post-mine closure, it is important to bear in mind that the effects of mining, and especially the production of acid mine drainage,

is likely to persist for centuries after mine closure (McCarthy and Pretorius, 2009). Efforts (as presented in this section) have been made by mining companies in collaboration with government and local communities to try and respond to the concerns about coal mining, particularly for AMD pollution.

2.3.1 Mining Company Initiatives

Several approaches, techniques and principles have been adopted and implemented by mining companies with a view to avoiding negative impact on the environment and communities in which they operate. With greater awareness and stricter environmental laws, mining companies have paid more attention to community projects, as well as environmental practices and strategies, including the development of technologies for air quality management (including the reduction of dust and methane emissions), water and waste management, and strategies for rehabilitation and closure.

- ***Mine Waste Management***

The South African Coal Road Map (SACRM, 2011) provides details on how the management of waste has evolved over the years, mostly in response to growing concerns about the impacts of coal mining. Mining companies have adopted the “avoid, reduce, reuse and recycle” management hierarchy to ensure minimal impact on human health and the environment during operations and post closure. For instance, spontaneous combustion from waste dumps can be prevented by limiting contact with oxygen, regular monitoring of pile temperature, and reclaiming from stockpiles in a First-In-First-Out schedule (SACRM, 2011).

Several waste disposal methods have been realised and are being practised by mining companies. To reduce the chance of spontaneous combustion on dumps, discards are now spread and compacted to eliminate airflow into the dumps (SACRM, 2011). Further, for reclamation possibilities, the compacted discards are now co-disposed with ultra-fine slurry, which is pumped into the centre of the discard dump, with the compacted discard forming a wall around the central slurry impoundment (SACRM, 2011). In a method called integrated disposal, the ultra-fine slurry may also be pumped onto un-compacted discards, to form a matrix that is non-oxidising. Discard facilities are also now being clad with soil and vegetated to prevent all forms of atmospheric pollution, and dumps are being constructed with run-off paddocks to control storm water run-off from (SACRM, 2011). Recycling and reclamation of discards and slurry to saleable coal products has become a standard practice for most mining

companies. Seepage from the dumps is now re-used in the processing plant or gravitated to evaporation dams (SACRM, 2011). Coal discard is reprocessed to extract low-grade steam coal, mainly for use in local power stations (SACRM, 2011). The ultra-fine slurry is beneficiated by froth flotation to produce power station feedstock, or dewatered for use in its raw state or even as an export product (SACRM, 2011).

Backfill can be used for environmental and economic factors, such as in the prevention of spontaneous combustion, for stabilisation of rock, to improve mine ventilation, to reduce subsidence effects at the surface, and as construction material. The use of coal ash to backfill mine voids has also gained attention by mining companies; this dates back to 1963 when coal pillars in Koorfontein Colliery in the Witbank were stabilised (Ward et al., 2006). According to Ward et al. (2006) backfill technology in South Africa has advanced since the 1980s. Sasol Mining took the initiative to reduce the risks associated with the subsidence of its old Sigma Colliery workings in the Sasolburg district. According to Digby Wells Environmental (2013), the Colliery backfilled mine workings located beneath the Sasolburg-Parys Road (R26) and certain privately owned farms, in order to minimise the safety risk in the area. Another project was proposed to stabilise old underground mine workings which are an additional risk to land subsidence in the area (Digby Wells Environmental, 2013). This project entailed dewatering mine voids treating the water at a planned Sasol Group water treatment plant, and filling the voids with ash slurry from the Sasol Ash pump station at Sasol Chemical Industries (Digby Wells Environmental, 2013).

Sasol Mining, in collaboration with the Mpumalanga Economic Development Department and the Goven Mbeki municipality, also embarked on a construction project that uses coal fly ash to make bricks (Yende, 2016). The brick factory buys 1000 tons of fly ash from Sasol, mixes it with cement and water to produce hollow-block and maxi bricks. Not only has this project reduced the waste output and its effects on the environment and local community, but it has further created job opportunities in the area (Yende, 2016).

- ***Mine Water Management***

The impact of coal mining on water quality is considered to be the industry's most severe environmental impact and AMD is the most significant water quality concern. As the impacts of AMD become more visible, much research has been focused on developing mitigation measures and considerable initiatives have been undertaken to prevent, reduce and remediate its effects. It has been found that the impacts can be minimized at three basic levels: (i)

through primary prevention of the acid-generating process; (ii) through secondary control, which involves deployment of acid drainage migration prevention measures; and (iii) through tertiary control, or the collection and treatment of effluent (Akcil and Koldas, 2006).

In this regard, Anglo Coal, BHP Billiton Energy Coal South Africa (BECSA) and the eMalahleni Municipality embarked on a joint initiative to recover potable water from AMD discharge from four mines in the eMalahleni (Witbank) area (Hutton et al., 2009; Bradford and Salmon, 2007). Through a pre-consultation process, relevant stakeholders at both national and regional levels engaged and formed an Authorities Steering Committee to identify activities and manage approvals for the plant (Sergienko, 2017). Approvals from the DMR, DWS and DEA were obtained through discussions held with the Committee (Sergienko, 2017). The operational eMalahleni Water Reclamation Plant (EWRP) project was commissioned in September 2007 (Figure 2-7) and receives its feed of water from four coal mines in the area, namely the Greenside Colliery, Kleinkopje Colliery, South Witbank Colliery and Navigation Colliery. The water recovery is done using the Key Plan Hi Recovery Precipitating Reverse Osmosis (HiPRO) process which involves low chemical and energy input as it uses membranes only as the recovery unit operation (Hutton et al., 2009).



Figure 2-7: The eMalahleni Water Reclamation Plant at construction phase
(www.aveng.co.za)

Through the recovery of potable water and ensuring positive waste production and utilization, the treatment plant aims to reduce the pollution of water sources and provide high quality water not only for local municipality use but also to the Upper Olifants Catchment. The plant

currently purifies 30 m³/ day to potable quality and covers almost 20% of the total potable water demand (Sergienko, 2017). Hutton et al. (2009) report that *“the highest average daily production in a month was achieved in September 2008 with a value of 24.2 ML/day. Further de-bottlenecking is being done to fully realize the 25 ML/day target. A liquid waste production of less than 1% has been successfully achieved, even achieving monthly values in the order of 99.5%. This has increased the overall recovery design value from 97% to >99.0%”*. Not only does the project supply potable water but 25 full time jobs were created to operate the plant (Bradford and Salmon, 2007). The project is operating successfully with constant monitoring, routine maintenance and safety at the centre of its function. Its success and impact has been recognised through several awards, including a gold medal by the South African Institute for Engineers (Hutton et al., 2009), a Mail & Guardian’s Greening Future Award, and the sustainability category of Nedbank Capital’s Green Mining Awards (Bradford and Salmon, 2007).

Various measures have and are being implemented to try to mitigate the deteriorating water quality in the Olifants River (McCarthy and Pretorius, 2009). As the world’s first plant the EWRP has served as a reference base for other projects with similar objectives. Similar efforts have been undertaken by BESCA for the Optimum Open-cast Coal Mine situated in Pullenshope, Mpumalanga. The Optimum Water Reclamation Plant (OWRP) also uses the HiPRO Process to treat excess mine water to drinking standard (Cogho and Karakatsanis, 2010; Cogho, 2012). OWRP also uses the large scale technology used at the EWRP with the aim of recovering 98% of the mine water to high quality drinking water with minimal waste generation (Cogho, 2012). The project is comprised of 4 stages: (1) mine water collection and transfer, in which the feed water is sourced from the evaporation dam situated about 2 km from the treatment plant, (2) the mine water treatment plant, which includes pre-treatment, ultrafiltration and reverse osmosis to produce treated water of potable quality, (3) treated water collection and distribution where the mine produces 15ML/day of treated water with a peak capacity of 18.75 ML/day and (4) waste disposal where the remaining water waste stream in the form of a mixed sludge, gypsum and brine is disposed (Cogho and Karakatsanis, 2010; Cogho, 2012). With the success of the project came a five year water supply agreement between BECSA and the Steve Tshwete Local Municipality for BECSA subject to the supply of 3ML/day of drinking quality water based on the set SANS/SABS water quality specifications and priced at municipal tariffs (Cogho, 2012).

- ***Land Rehabilitation***

Rehabilitation refers to the process of restoring land that has been impacted by mining activities back to a sustainable usable condition (Chamber of Mines of South Africa and CoalTech, 2007). Rehabilitation activities by mining companies have achieved mixed results. A guideline for the rehabilitation of land disturbed by surface coal mining was first published by the Chamber of Mines in 1981 (Chamber of Mines of South Africa and CoalTech, 2007). New guidelines have since been produced to update the previous guidelines which, according to the Chamber of Mines of South Africa and CoalTech (2007), consist of the current best practices on how to go about achieving satisfactory, sustainable rehabilitation for all forms of mining and all mineral industries in South Africa and internationally. However, effective long-term rehabilitation —that is, rehabilitation that will be sustainable in the long term under normal land management practices — is yet to be proven. Many experts worry that it is unlikely that the degraded land will ever be returned to its former state (GDACE, 2008; GroundUp and Davies, 2014).

Revegetation is a particularly challenging aspect of rehabilitation. Another challenge is the availability of plant species that can tolerate the potentially acidic or highly saline conditions prevalent on coal mining sites (Sarma, 2005). Topsoil, harvested prior to the commencement of activities, is limited and may often be contaminated or physically altered. Compaction of replaced topsoil, in particular, is reported to hamper revegetation efforts (SACRM, 2011).

Despite these challenges, many mining companies have made concerted efforts to improve their rehabilitation efforts. Glencore Coal South Africa took the initiative to rehabilitate the Voorslag Farm section of the Spitzkop Mine, whose operations had ceased in 1984 and had been poorly rehabilitated (<http://www.glencore.com>). The site had become derelict with poor water quality, eroded infertile soils and limited vegetation. In the early 2000s, efforts were made to restore the soil fertility, land capability and water quality at the site. A biodiversity management plan that included alien plant control and wildlife management was also developed. The water quality was improved to a neutral pH status and levels of sulphate runoff were reduced through developing a water improvement system and a long-term water management strategy (<http://www.glencore.com>). Anglo American recently reported success in land capability from its rehabilitation work at Kriel Coal Colliery in Mpumalanga. Initially as a trial in 2014, maize was planted on 400 hectares of rehabilitated land with a successful harvest, after which soya beans were also successfully planted and harvested on the same

land. The decision to plant soya was based on the view that it can improve the soil's nitrate concentration, which means that fertilizers would not need to be used in the next stage of the crop rotation cycle. The next phase of the mine's study will look into assessing and addressing soil nutrient deficiencies and any other factors that could impact crop yields (<http://www.angloamerican.com>).

- ***Community Health***

Sustainability is a complex process, particularly when it involves multiple competing uses. Coal utilisation is essential but still requires the use of land and water sources on which communities depend and also impacts on health and livelihoods. Anglo Coal is committed to several sustainable community investment projects including minimising air pollution (Balmer, 2007), the use of new water, reducing waste and promoting re-use and recycling (Bradford and Salmon, 2007). Several projects across the globe have been initiated in partnership with local communities. In China, a joint initiative was set up between Anglo Coal and PLAN, an NGO focusing on community development, to increase access to potable water and sanitation infrastructure in three local villages (Bradford and Salmon, 2007). The project was aimed at providing families with access to reliable and safe water supply. Following the air pollution caused by domestic coal use, and its impacts on households, Anglo Coal initiated a funded project in the Vosman Township near Witbank in Mpumalanga, South Africa (Balmer, 2007) to make the use of coal safer and less harmful to individuals and the environment. Anglo Coal appointed a private research and consulting firm to implement a demonstration and training programme on an alternative fire lighting method called “*Basa Njengo Magogo*”, also known as “top-lit up-draft stoves”, to 10 000 households. To minimise ambient air pollution caused by the use of household coal, the method involves stacking a coal fire differently and lighting from the top (Balmer, 2007). According to Balmer (2007), this method has the potential to eliminate more than 80% of smoke, and not only has an impact on health but when implemented on a wide scale can result in coal and monetary savings for low-income households (Balmer, 2007).

2.3.2 Government Initiatives

As discussed in section 1.1.1, the South African mining sector is regulated by legislation to ensure responsible mining practises by mining companies. There have been several legislative reforms over the years and regulations have become more stringent, placing as much priority on social and environmental well-being as on the economic benefit of mining.

The Minerals and Petroleum Resources Development Act (MPRDA) (Act 28 of 2002), administered by the DMR, succeeded the Minerals Act No. 50 of 1991, which provided a basis for environmental management for the first time in South Africa (Limpitlaw et al., 2005). The MPRDA required mines to develop an Environmental Management Programme Report (EMPR), with an Environmental Management Plan stipulating monitoring and evaluation arrangements and financial plans guaranteeing social and labour plans, rehabilitation and closure. Until December 2014, the MPRDA governed the environmental management of mining. Government then instituted a law reform process—environmental regulation would be implemented through a “One Environmental System (OES)” aimed at streamlining an environmental management approach that will integrate all sectors including the mining sector. On the 8th of December 2014, government transferred the environmental regulation of mining from the MPRDA to the NEMA (OSF, 2015). However, the mandate to enforce the environmental regulation relating to prospecting, exploration, mining or production operations (Retief, 2017), including issuing of environmental authorisations and waste management licences, remained with the DMR (CER, 2016b; OSF, 2015). The DEA would only set the environmental regulatory framework, norms and standards for environmental management, excluding water (Retief, 2017). The centralised approach of the OES has received criticism from environmental experts, the mining industry and CSOs. Concerns have been around effective enforcement and capacity within the DMR, and the will to ensure environmental compliance and monitoring (Khosa, 2017; OSF, 2015; CER, 2016b). *“If the DMR’s capacity to carry out an environmental compliance monitoring and enforcement function was extremely compromised in an MPRDA context, without significant additional investment, it is difficult to see that it will not be even more compromised after these amendments”* (OSF, 2015). The amendment has also been considered confusing and a conflict of interest between the sector departments in terms of core objectives—the DMR *“cannot manage environmental and social costs of mining as that would defeat its core objectives”* (Schutte, 2014). Moreover, additional amendments to key legislation have been necessary and are on-going, which according to the CER (2016b) are creating loopholes that mining companies have been quick to exploit.

Mineral waste management (for residue stockpiles and deposits) had been regulated under the MPRDA whilst other forms of waste generated by the mines were regulated under the National Environmental Management: Waste Amendment Act (NEMWA) 59 of 2008

(Senkhane, 2015; Becker, 2015; Muir, 2017). In 2014, mineral waste regulation under the MPRDA was streamlined into NEMWA and the National Environmental Management: Waste Amendment Act 26 of 2014 came to effect. Prior to the streamlining, the MPRDA waste regulations only required water use licences and an environmental management plan, whilst the revised Act of 2014 requires waste management licences (Senkhane, 2015; Becker, 2015). The provisions under NEMWA have also been criticised by environmental experts, the mining industry and CSOs for containing vague and ambiguous prescripts and for their potential significant cost implications (Senkhane, 2015; Becker, 2015). The new set standards for waste management have been found to be lacking in terms of waste classification whilst disregarding the technicalities required for waste disposal. The revised Act predefines mineral waste as hazardous but still applies the same technical requirements of small landfills to larger mine deposits (Senkhane, 2015). Mineral waste has a larger disposal footprint and would therefore require different (and potentially costly) designs rather than disposal of waste in the landfill designs (Senkhane, 2015; Becker, 2015; Muir, 2017).

In South Africa, rehabilitation objectives ought to align with the national and regional Integrated Development Plans (IDPs) as well as with EMP and Closure Plan objectives and commitments, and must provide for a sustainable post-mining land use. To ensure that local community wishes are met, a public participation process is undertaken during which consensus may be reached and permission to mine is granted. In addition, the removal of environmental authorisation legislation from the MPRDA into the NEMA was also done to create one environmental system of laws that govern the mining industry's rehabilitation obligations. According to Mining Review Africa (2016), under the old regulation mines had to submit an interim closure and final closure plan; NEMA now requires three closure plans:

- The annual rehabilitation plan: lists the on-going rehabilitation activities required during the operational life of mine;
- The final rehabilitation, decommissioning and closure plan: includes details of the final rehabilitation and 'use of land' post-closure; and
- The post-closure plan: requires that the mine conduct an environmental risk assessment of latent and residual environmental impacts, covering an indefinite post-closure period.

The previous regulations under the MPRDA did not require post-closure liability, however, with the new regulations under NEMA the liability of the mine continues post-closure, especially where the treatment of water is required. Mining companies that do not comply will be subject to fines of up to R10 million, 10-year prison sentences or both (Mining Review Africa, 2016).

Section 100(2) (a) of the MPRDA provides for the development of the Mining Charter as an instrument to facilitate the sustainable transformation, growth and development of the mining industry with specific targets (Draft Mining Charter, 2016). Operation Phakisa, a South African government initiative to fast track the implementation of development issues by economic sectors including the mining sector was introduced to the public by the President in July 2014 (<http://www.operationphakisa.gov.za>). Operation Phakisa, administered through the Department of Planning, Monitoring and Evaluation, aims to accelerate the execution of the National Development Plan, particularly to increase the country's GDP by 2033. The Mining Phakisa which took place for 5 weeks in late 2015 was intended to address issues undermining the competitiveness of the sector (Mining Weekly, 2015). Implementation strategies for the long term development and transformation of the mining sector were designed through a laboratory process in which key stakeholders from the public and private sectors, academia, and civil society organisations collaborated (<http://www.operationphakisa.gov.za>). Within the sector, the initiative targeted promoting investment into the sector, greater exploration activities, participation of emerging miners, jobs and skills development, infrastructure, social and community development and research, development and innovation (DPME, 2017; Mining Weekly, 2015). Mine rehabilitation intervention is also an area of focus within Mining Phakisa. The initiative has, however, received some scepticism among mining leaders, who have expressed doubts about its practicality (Miningmx, 2015) .

The Revitalisation of Distressed Mining Communities Programme is another government initiative aimed at improving socio-economic challenges in mining towns and their labour sending areas. The programme forms part of the Special Presidential Package (SPP) Social Accord signed between government, business and labour in October 2012 (DPME, 2017). Nineteen mining areas in six provinces, namely the Northern Cape, Free State, Gauteng, Limpopo, Mpumalanga and North West, and their associated labour sending areas, have been prioritised for the programme. In the KwaZulu-Natal and Eastern Cape Provinces, 12 labour sending areas have also been prioritised (DPME, 2017). The programme focuses on:

1. Integrated and sustainable human settlements, led by the Department of Human Settlements and supported by its agencies;
2. Improved socio-economic conditions, led by the Department of Trade and Industry, the Department of Co-operative Governance, the Department of Traditional affairs, and the Department Rural Development and Land Reform;
3. Improved working conditions of mine workers, led by the Department of Labour; and
4. Decent living conditions for mine workers and meaningful contribution to the development trajectory of mining towns and labour sending areas, led by Department of Mineral Resources (DPME, 2017)

Since the inception of the SPP in 2012, several reviews have been made and solutions successfully implemented in each focus area. In terms of human settlements, a state-supported mine worker housing model and funded infrastructure provision projects (housing, water and sanitation) were implemented. In 2015, the Presidency reported that 66 public sector housing projects were already underway (<http://www.politicsweb.co.za>). Economic development projects including large-and small-scale industrial projects aimed at creating businesses and employment opportunities have been implemented. Industrial and infrastructure development plans have been developed and coordinated with municipal economic development plans (DPME, 2017). Improvements were also made to the compensation systems and on occupational health and safety of former and current mineworkers. Part of the programme was to evaluate the relevance and effectiveness of the environmental governance legislation in mining and the implementation of the Mining Charter, in order to strengthen the realization of the objectives within the Charter (<http://www.politicsweb.co.za>).

As can be seen from the discussions above, various amendments relating to the mining industry have been made to the NEMA. The Mining Charter was reviewed and a draft gazetted for public comment by the DMR in April 2016. The contents of the draft Charter have, however, received strong criticism from the Chamber of Mines, mining analysts and mining companies (Brown, 2016). These criticisms, amongst others, include (1) the lack of stakeholder engagement in developing the Charter, and (2) the contention that the new regulations such as ownership and procurement targets are considered to be unworkable and not achievable and inconsiderate of the viability of the sector (Peyper, 2017; Brown 2016).

The release of the final updated Charter initially set for the end of March 2017 was delayed (Peyper, 2017); it was finally gazetted on the 15th of June 2017.

2.4 Summary and Synthesis

Historically coal mining has had a significant impact on the environment and there is plenty of documented evidence to support this. These impacts can be largely associated with water quality, physical and chemical land degradation, and air pollution through emissions of particulate matter (PM) and toxic gases. The published literature also provides fairly substantive evidence that this environmental pollution may, and often does, have an adverse effect on local eco-systems as well as on community health and livelihoods, particularly though crop and livestock farming. In particular, AMD from coal mining results in significant pollution of land and water resources. Water that is contaminated by AMD is unsuitable for both human and animal consumption; the acidity and toxicity of the water disrupts metabolic functions, leading to adverse health effects and the death of aquatic life. Contamination of soils by AMD may affect fertility and in turn hinder plant growth and crop quality. Dust and gaseous emissions from coal mining and residential coal use can impact on human health, through the inhalation of particulate matter containing quartz and pyrite (dust), and volatile toxic elements (gaseous emissions). Dust from coal mining is also reported to have a significant effect on crop productivity.

However, whilst several studies have indicated that there is a strong link between environmental pollution from mining activities and the health and well-being of humans and eco-systems in the surrounding vicinities, there appear to be few detailed cause-effect studies of specific incidences, particularly in the South African context. This may be due to the fact that such studies are fraught with complexity due to the large number of location-specific influencing factors and the large temporal and spatial scales involved. The nature and intensity of the impacts vary depending on the characteristics of the coal deposit, the volume extracted, the waste outputs, the mining method and practices of the operations— particularly in terms of the environmental management practices —and the proximity of the communities to the mine and/or contaminated environments. Socio-political and socio-economic issues may also play a role in influencing perceptions, concerns and conflicts regarding coal mining. The ability to identify causal effects is exasperated by the lack of publically available quantitative data and information, particularly in terms of the composition, toxicology and

epidemiology of environmental emissions associated with coal mining and processing. The availability of scientific and numerical data notwithstanding, the public literature bears testimony to the adverse impacts of coal mining on local communities and the environment in the South African context. The increasing publicity of the impacts of coal mining is largely as a result of the activities of the relatively large number of civil society organisations that now exist with the purpose of protecting the local environment and communities against “injustices” by mining companies. There is also evidence of positive response to these concerns by Government and mining companies, particularly the larger multi-national companies. These responses include significant legislative and regulatory reforms, as well as the rehabilitation of degraded lands, improved waste management practices and the treatment of contaminated mine water.

However, reports in the open literature also reflect doubts about the ability of government to implement and enforce regulations in a consistent and fair manner, and on the effectiveness of interventions by mining company. Furthermore, for the most part, local environments remain polluted and mining communities continue to suffer, resulting in a highly politicised scenario and on-going (and possibly escalating) conflicts between communities, mining companies and local government. Incidents and conflicts around the impacts of coal mining have been observed across the country. These conflicts relate mainly to water consumption, the pollution of air and water, and the impacts of pollution on farming activities. Other common points of conflict include safety risks due to unrehabilitated and physically unstable land and the effects of blasting on buildings. It is also noted that much of the conflict seems to be around defunct and/or junior operations, who mostly mine old underground mines. As already discussed, there appears to be relatively little quantitative data and information to support the reports of environmental and social injustice.

CHAPTER 3

STAKEHOLDER PERCEPTIONS AND EXPERIENCES

Chapter 2 presented the findings of the review and assessment of published literature with respect to the impacts associated with coal mining, both globally and locally, as well as national incidents and conflicts, and the responses to such. This chapter presents the results of the semi-structured interviews with relevant stakeholders (Phase 2 of the study), describes the study area and the methodology used for data collection, and presents more evidence as findings from the field work undertaken to establish perceptions and concerns amongst communities with respect to the mine-environment-community cause-effect chain and any current and emergent responses to the environmental and social impact concerns. This was gathered through a case study investigation in the Mpumalanga Province which included semi-structured interviews with representatives from communities, civil society organisations and independent environmental consultants.

3.1 Stakeholder Engagement Methodology

Stakeholder engagement took the form of semi-structured interviews with selected community members, representatives of civil society organisations and independent environmental consultants, all of whom are actively involved in the coal mining activities within the Mpumalanga Province of South Africa. These interviews were conducted with a view to establishing a deeper understanding of local communities' views pertaining to:

- (i) the environmental and social impacts associated with coal mining and processing activities in the Mpumalanga Province;
- (ii) the extent to which such concerns are being/have been reported and addressed; and
- (iii) stakeholder (government, company and CSOs) roles and mitigating actions and approaches.

This section of the dissertation provides details on the Mpumalanga area under investigation (3.1.1), the stakeholders interviewed (3.1.2), and the interview process (3.1.3).

3.1.1 Case Study Area

The study investigates the environmental and social impacts from coal mining in the Mpumalanga Province to develop a more detailed understanding of the cause-effect-relationship between coal mining, the environment and community quality of life. Coal mining in South Africa began in the 1870s when it provided the energy for diamond and gold mining and associated industry and infrastructure, including the railways. The industry developed in the 1970s with the expansion of investments in electricity generation brought about by higher labour costs, following increased unionisation, and changes in government policy which promoted mechanisation, domestic energy security and increased exports (Eberhard, 2011). The economy in the Mpumalanga Province is dominated by mining: in 2014, mining accounted for 22% of the provincial economy, followed by manufacturing at 12%, construction at 3%, and agriculture at 3% (The Real Economy Bulletin, 2016).

Coal mining is one of the development drivers within the Mpumalanga Province; it supports the growth of the economy and creates jobs. By 2007, there were 73 collieries in the country, and 61 of these were located in Mpumalanga (Pooe and Mathu, 2011). According to the CER, in 2015 there were 239 operating mines and 788 derelict and ownerless mines in Mpumalanga (CER, 2016b). The major coal mining areas (Figure 3-1) are currently in and around the towns of eMalahleni, Middelburg, Ermelo, Standerton and Secunda (Jeffrey, 2005b). Witbank (eMalahleni) is considered the supreme coalfield at present. By 1889, four small colliers; namely Brugspruit, Steenkoolspruit, Maggie's Mine and Douglas Colliery, were already operating in the Witbank coalfield (Jeffrey, 2005b) and by 1920 the Witbank Colliery had acquired a ten-year license to generate electricity for the town with a new power station being established by 1925 (www.sacities.net).

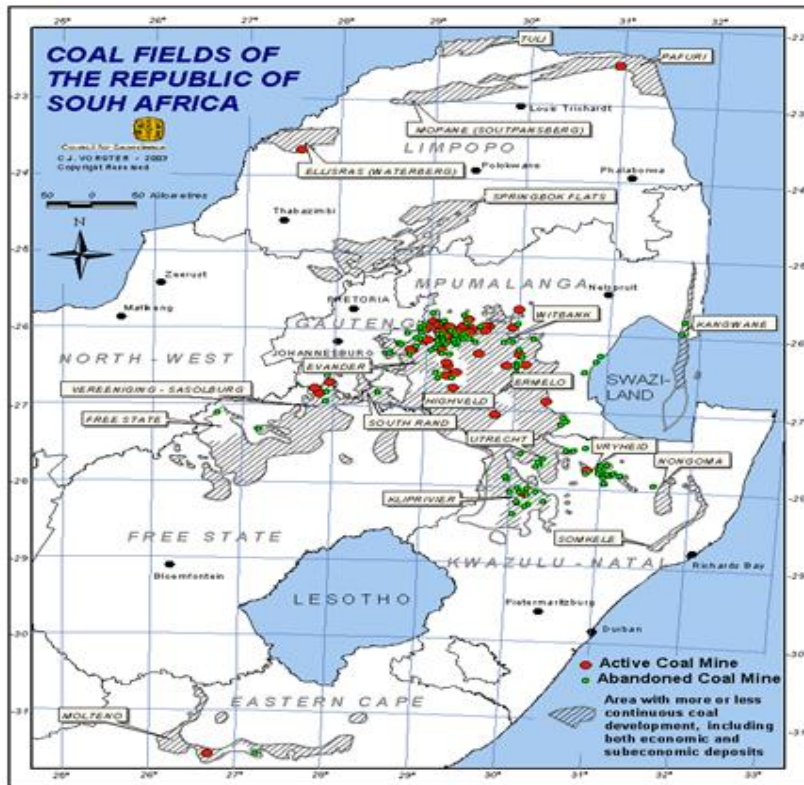


Figure 3-1: Map showing cluster of operational and abandoned mines in Mpumalanga, South Africa (<http://www.geoscience.org.za/index.php/publication/downloadable-material>)

The largest industrial companies are located in the Witbank area and include a remarkably high number of coalmines and power stations: there are 22 mines in the area within a radius of no more than 20 km, and 12 coal-fired power stations out of the 16 in the country (ActionAid, 2014; Mining Weekly, 2010). The air quality of the Province, particularly on the Highveld, is among the worst in the country due to coal mining and other industrial activities such as power generation, coal-to-liquids conversion, heavy metals (steel and ferroalloys) manufacturing, transport and agriculture (Dlamini, 2007; CER, 2016a; CER, 2016b). Not only does the Mpumalanga Province coalfield account for over 84% of South Africa's coal production (Mining Weekly, 2010), it also contains 46.4% of the country's major arable soils and is the heart of maize production.

3.1.2 Description of Participants

As indicated, selected participants included community members (participants 1-2, with participant 2 comprising a group of 3 community activists), representatives of civil society organisations (CSOs, participants 3, 4, 5, 9 and 10) and professional environmental

consultants (participants 6, 7 and 8) actively involved in services and programmes relating to environmental and social justice in the context of coal mining within the Mpumalanga Province. Further details pertaining to the participants are presented in Table 3-1.

Table 3-1: Participant details

Participant ID	Organisation	Location	Role/ Level of Expertise
Participant 1	Community	Mpumalanga	Activist in affected communities
Participant 2: (in individual capacities as part of a group)	Community	Mpumalanga	Activist in affected communities
	Community	Gauteng	Community Liaison
	Community	Mpumalanga	Activist in affected communities
Participant 3	CSO	Gauteng	Education & organisation of affected communities in Mpumalanga
Participant 4	CSO	Gauteng	Lead researcher on community impacts associated with mining, including coal mining in Mpumalanga
Participant 5	CSO	Gauteng	CEO with extensive experience in human rights advocacy and environmental risks in mining affected communities
Participant 6	Environment Consultancy	Gauteng	Considerable experience and expertise in environmental issues associated with impacts associated with the mining sector
Participant 7	Environmental & Social Services Consultancy (Mineral resources)	Gauteng	CEO/Expert in environmental and social impact assessments in Mpumalanga
Participant 8	Environment Consultancy	Gauteng	Expert in water and energy-related issues associated with mining, including coal mining in Mpumalanga
Participant 9	CSO	Western Cape	Head of mining sector/expertise in environmental litigation, with experience in Mpumalanga
Participant 10	CSO	KwaZulu Natal	Considerable experience on environmental and social issues associated with impacts associated with the coal mining sector

Although relatively limited in number (twelve in total), these participants all have extensive experience and/or expertise of relevance to this study and can thus be considered to provide adequate representation of the general understanding and perceptions amongst the communities. Participants 1 and 2 (group) were representatives of coal mining communities, whilst participants 4 to 10 were representatives of civil society organisations (non-governmental and non-profit organisations) and consultancies.

3.1.3 Interview Process

As already indicated, stakeholder engagement took the form of semi-structured interviews, allowing further interaction and discussion of responses. Prior to the interview, participants were contacted by email requesting their participation in the study, and providing them with a brief project background. A questionnaire (Appendix A) was developed to facilitate the interview process. Part A of the questionnaire consists of pre-set variables from which participants had to rate their responses using a Likert scale, whilst part B consists of simple but comprehensive open ended questions which allowed participants to express their views and understanding of the impacts and risks associated with coal mining. Prior to conducting the interviews, the research abstract, a copy of the consent form (Appendix B), and the interview schedule (Appendix A) were made available to the participants to ensure that they understood the objectives of the study and to give them the opportunity to ask any questions about the project and their participation. Participants were informed of the procedures regarding confidentiality and of the audio-recording of interviews. This ensured that they made an informed decision to participate voluntarily. The anonymity of was guaranteed, and the researcher did not collect data that was outside the purpose of the research.

Of the 10 interviews conducted, nine were conducted face-to-face and one took the form of an electronic interview, involving a combination of email and telephonic correspondence. The interviews lasted between 45 minutes and one hour and were conducted at the participants' preferred location. One interview took the form of a group discussion with three community representatives after conducting a field tour around the Witbank (eMalahleni) area in Mpumalanga. Participants did not have to fill-in or do any writing except for signing the informed consent form (Appendix B) prior to undertaking the interviews. All the face-to-

face interviews were audio-recorded and later transcribed for purposes of accurate interpretation and quoting where applicable.

The research complied with the ethical practises as prescribed by the University of Cape Town. Prior to data collection, and to ensure compliance, the proposed research was reviewed by the Engineering and Built Environment Ethics in Research Committee (EiRC). Approval was granted by the EiRC and a copy of the Ethics form is attached (Appendix C).

3.2 Stakeholder Concerns on the Environmental and Social Impacts

The semi-structured interviews served to establish stakeholder perceptions, concerns and understanding on the impacts and risks relating to coal mining.

3.2.1 Concerns on Specific Environmental and Social Impacts

Section A of the interview schedule lists specific issues arising from coal mining and processing, which the participants were required to rate according to their perceived relative risk (from very low to very high). The participants were subsequently invited to elaborate on their understandings and concerns regarding the specific environmental and social impacts ranked in the previous section. Table 3-2 presents the results from the ratings, indicating how many participants rated the risks and impacts from 1 to 5, with 5 being a very high risk and 1 a very low risk.

Overall the risks were rated as high to very high by the majority of the participants, for all issues listed. As shown in Table 3-2, 80% of the participants rated coal mining as posing a very high risk to land, including occupation and pollution, surface water quality and soil fertility. Risks to aquatic life, human health, underground water quality and air quality were also rated as very high by 70% of the participants. All community and CSO representatives rated all the risks as high to very high for all the issues, whilst the professional environmental consultants (participants 6, 7 and 8) had differing opinions rating issues from very low to very high risk. In particular, all the consultants rated the risk to water consumption a low risk.

A more detailed analysis of the participants' ratings and discussions of the specific environmental and social issues is provided in the following sub-sections.

Table 3-2: Rating of impacts and risks

Risk/Impact	No of respondents ranking risks at different levels				
	1	2	3	4	5
Land occupation/loss				2	8
Subsidence (ground stability)			1	4	5
Land pollution & erosion			2		8
Air pollution		1	2		7
Dust			2	2	6
Water consumption		3			7
Surface water quality				2	8
Underground water quality		1		2	7
Human health	1		1	1	7
Livestock production		2	1	2	5
Soil fertility			1	1	8
Crop production	1			3	6
Aquatic life				3	7
Where: 1 = very low risk; 2 = low risk; 3 = moderate risk; 4= high risk; and 5 = very high risk					

- ***Land Occupation and Degradation***

Loss of useable land occurs through both occupation and degradation as a result of pollution, erosion and subsidence. The results of the survey with respect to land occupation and degradation issues are presented in Figure 3-2.

As discussed in Section 3.2.1, the risks and impacts of coal mining on land occupation and loss, as well as on land pollution and erosion, were rated as very high by 80% of the participants. Land subsidence was also rated as a high to very high risk by 90% of the

participants, and was perceived to occur mostly as a result of abandoned mines and lack of proper rehabilitation.

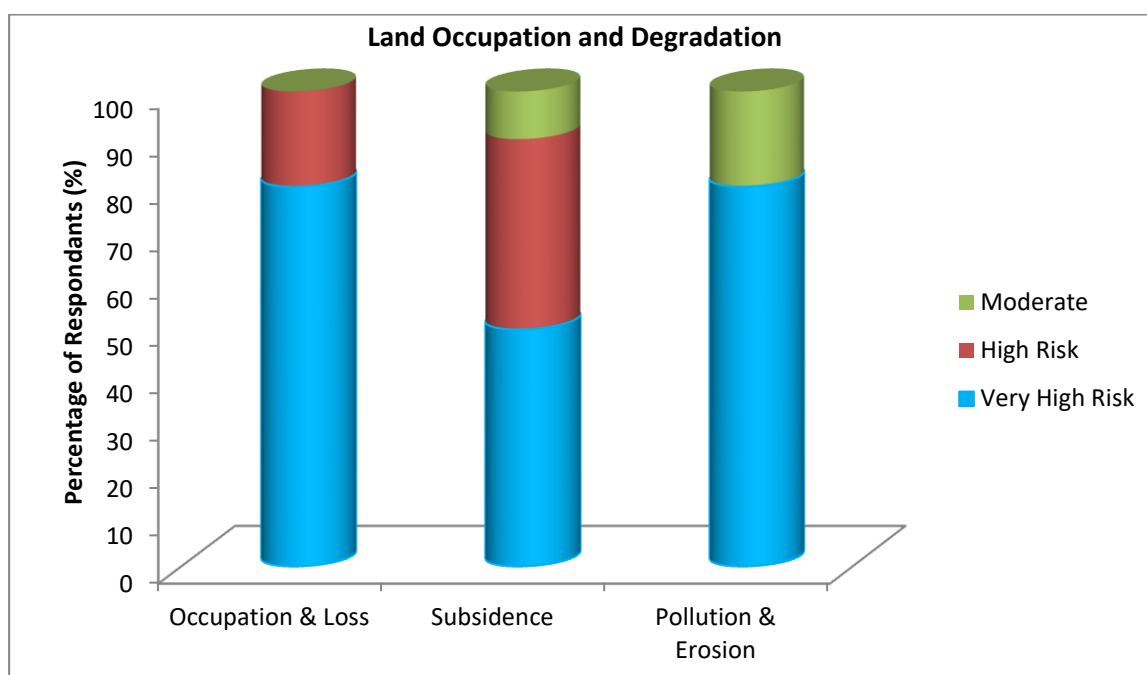


Figure 3-2: Land occupation and degradation ratings

Participant concerns in terms of land centred largely on relocation and resettlement, the loss of productive land, and land use change, both during and after mining.

“Very high productive land is taken up by open-cast coal mining” - Participant 7

“In any case land is lost because of the scale at which mining occurs in South Africa”- Participant 9

“Mining is always 100% destructive and it will always have a fundamental change in land use before and after mining” - Participant 8.

Issues of relocation and resettlement were most important to community activists (participants 1 and 2). In addition, participant 4 felt that the occupation of land by informal settlements was also a big issue, especially in areas of customary law. In terms of land degradation, subsidence was generally considered to be a significant issue in the Mpumalanga Province, particularly with respect to abandoned mines that have not been adequately rehabilitated. The occurrence of subsidence as articulated by participants (5, 8 and 9) is due to inadequate backfilling, that may either be insufficient and to a larger degree impossible, resulting in the collapse and formation of sinkholes. Moreover, the depth and

type of mining employed were also mentioned as factors that affect the severity and likelihood of subsidence occurring. Three of the participants (6, 7 and 9) noted that underground mining was more likely to result in sinkholes from subsidence than surface mining. In particular, in the case of abandoned underground mines, participant 4 referred to board-and-pillar mining as a major contributing factor to land subsidence. Furthermore, it was mentioned that the use of heavily loaded mine machinery and transport (participant 3) and illegal mining (participant 4) may also increase the likelihood of subsidence occurring. Two participants (9 and 10) expressed concern over the safety risks that land subsidence poses to communities and reported incidents where *“children had fallen into the sinkholes and old people burnt on their feet”* - Participant 10, and *“houses disappear into sinkholes, children and livestock fall and if there’s water at the bottom, there can be drowning”* - Participant 9.

Whilst land pollution and erosion were rated as very high risks by 80% of the participants, there were mixed responses as to how they are understood by participants. Some participants linked this to landscape changes in terms of loss of land cover and lack of rehabilitation (participants 1, 2 and 10) and the loss of productive land capacity (participant 7). Others attributed land pollution and erosion to mine waste deposits (including discard coal) and AMD (participants 4, 8 and 9).

“It is as a result of the process that occurs as the water acidifies from AMD generation thereby polluting the soils” - Participant 9.

“It can be significant and can be long term, it remains for geological ages” - Participant 5.

The most significant land-related issue for some participants (5, 6 and 7) was land restoration. The concern was that the land cannot be restored to its pre-mining state and that land capability drops from being arable. This restricts what can be done with the land post-mining in terms of supporting communities. *“It reduces sustainable livelihood opportunities and future land use”* - Participant 5.

However, the professional environmental consultants (participants 6, 7 and 8) noted that land-use change is manageable in theory, with participant 6 emphasising the possibility of rendering the land re-useable following adequate rehabilitation. Participants 7 and 9 mentioned that subsidence, in particular, could be avoided, or at least minimised, through proper rehabilitation post mine closure, using techniques such as backfilling. Considerable

concern was, however, expressed over the poor management of land and the lack of adequate rehabilitation efforts.

- **Air Pollution**

Air pollution was also considered a major impact from coal mining. Responses were related to dust fall-out from active mining operations (especially from blasting, mine transportation, machinery and equipment) and from gaseous emissions through spontaneous combustion of waste dumps and mine workings (Figure 3-3).

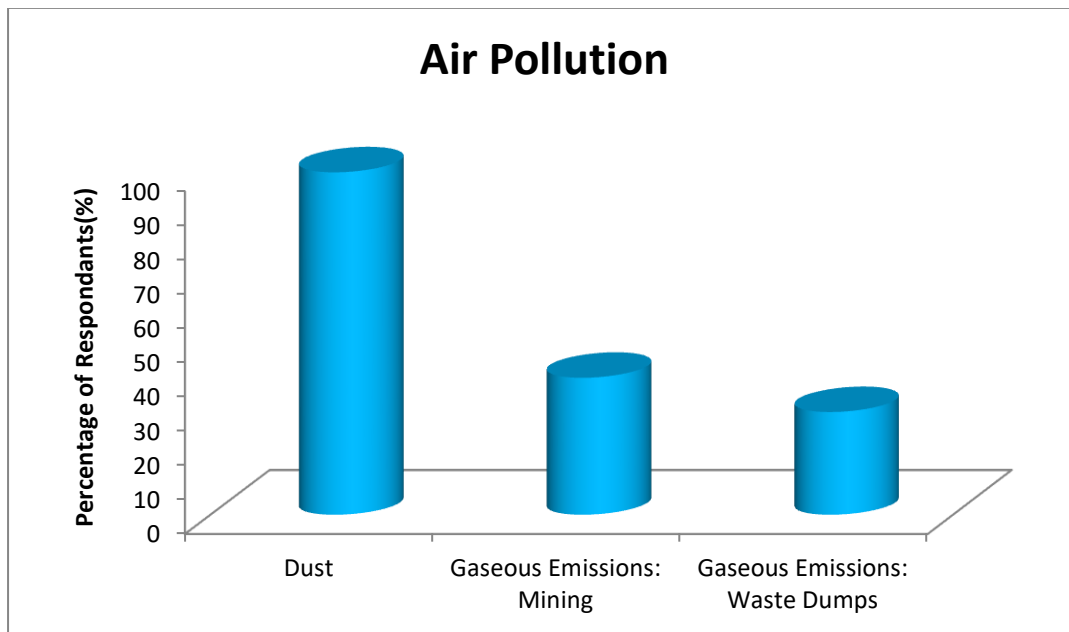


Figure 3-3: Perceived causes of air pollution

Overall, all the participants mentioned dust fall-out from active coal mines to be the major cause of air pollution. From the perspective of participant 5, the main problem in relation to dust pollution was that there is no requirement for the geochemical analysis of dust. Second to dust fall-out, was pollution due to emissions from mine workings. Only 30% of the participants (2, 8 and 10) mentioned air pollution from waste dumps through spontaneous combustion.

“It is a manageable problem associated with dust from active coal mines or where you have unrehabilitated dumps, particularly of carbonated waste that combusts and gets fires - that can be overcome if its rehabilitated”- Participant 9

- **Water Consumption**

Overall, there were mixed responses regarding water consumption by the coal mining industry. Whilst the professional environmental consultants (participants 6, 7 and 8) did not consider water consumption a major issue and rated it a low risk, the community and CSO representatives (participants 1- 5, 9 and 10) articulated that coal mines consume considerable quantities of water. The high use of water was attributed to coal processing operations, with the participants stating that a significant amount of water was used for washing, crushing, and in dust suppression.

“Coal mining is an intensive process, coal has to be washed, mined and crushed and that uses a lot of water”- Participant 9

“Mines use a significant amount of water which cannot be reused for consumption yet government blames households and farms for using more water and leaves out the mines”- Participant 2

“...they use tonnes and tonnes of water yet people go for weeks without water, the law says everyone has a right to clean water... government is doing nothing about it”- Participant 1

From an environment point of view, participants 3, 4 and 9 were concerned about the impact of water withdrawals by the mining operations on natural water sources, such as rivers, surface pans and groundwater aquifers. Participant 2 also mentioned the link between climate change and water scarcity; which will aggravate the competition for scarce water resources. Two of the professional environmental consultants (participants 6 and 8) highlighted the efforts by mining companies to minimise water withdrawals by adopting re-use and recycling approaches.

“Modern mines recycle every drop of water, it goes into a tailing facility and back into the plant”- Participant 6

“Mines are generally capable of generating their own water, it is possible to dewater coal seams and use that as part of processing water- the biggest user of water in coal mining is the dust suppression”- Participant 8

- **Water Quality**

Water quality was considered to be a key risk by all participants. This was particularly the case with surface water. However, participant 7 differed in perception about the risk to

ground water and considered it a low risk whilst other participants rated it a high to very high risk. Poor water quality was mainly linked to AMD, which was considered to pose a significant environmental and social risk. Participants 6 and 7 considered the effect of AMD on water quality to be particularly high in Mpumalanga due to the close proximity and longevity of the coal mining operations. Participant 6 highlighted the link between coal mining and the poor water quality of the Witbank Dam, which in turn is linked to that of the Olifants River and the Loskop Dam. At least one participant attributed coal residue deposits as a source of AMD pollution due to run-off and seepage. Participant 9 indicated that the wastes from residue stockpiles were a source of AMD pollution through seepage and run-off. Participant 8 attributed post-closure AMD risks to the failure of mining companies to ensure that there is sufficient neutralising capacity during rehabilitation.

The colour of the water, as described by participants 1 and 10, indicated that it was AMD polluted and rendered the water unsuitable for drinking purposes.

“The water from the taps is not clean, sometimes it is a brownish coffee-like colour and sometimes too much white, even an uneducated person can tell you”- Participant 1

- ***Human Health***

As can be seen in Figure 3-4, representatives from the community and the CSOs all considered coal mining to pose a significant risk to human health. These participants considered Mpumalanga an unhealthy place to live in, and asthma was a commonly mentioned health effect of coal mining.

“When you come to Mpumalanga, you get a strange headache and you struggle to breathe, you go back ill”- Participant 1

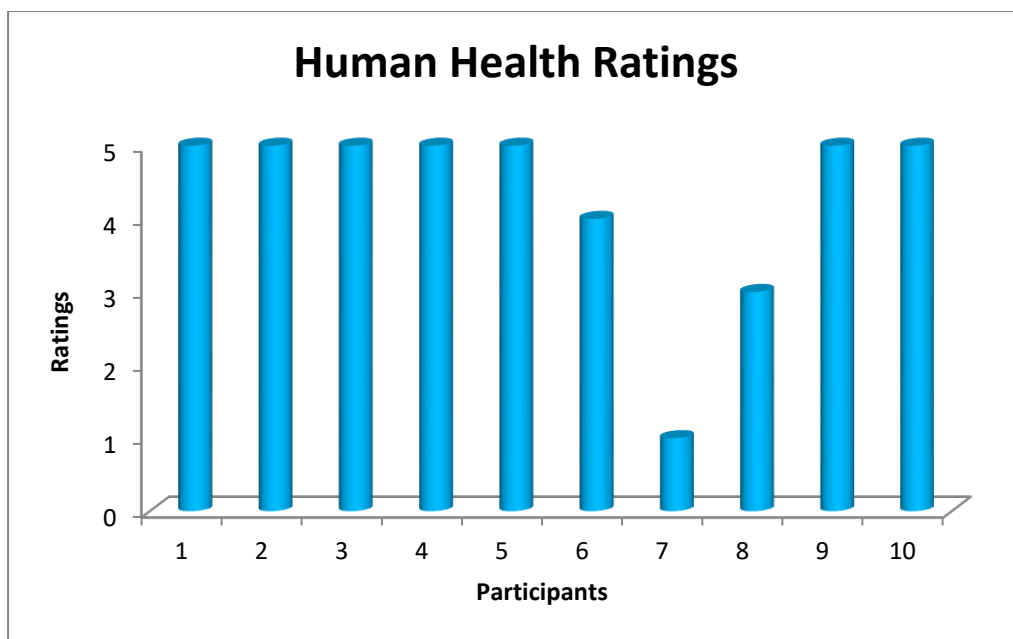


Figure 3-4: Human health ratings

The professional environmental consultants were less convinced of the health risks associated with coal mining, with their ratings varying from low to high. In particular, participant 7 considered coal mining not to have a significant impact on human health, due to the fact that communities are relocated and so there are few residential areas close to the mines.

The biggest health risk was attributed to air pollution by coal mine dust. The majority of the participants mentioned that the inhalation of coal dust leads to several respiratory problems, including asthma and chronic diseases such as cardiovascular and kidney diseases.

“My whole family has asthma, my father worked at the coal mines for years and he died from kidney failure, a kidney stone was found in his body”- Participant 2

Although air pollution was accorded as the major contributor, participants 1 and 6 were reluctant to generalise that health issues were purely as a result of air pollution from coal mines as there are other factors that may cause air pollution. It was also noted that the lower level of quartz meant that coal dust is less toxic than dust from hard rock mining (participant 6), whilst it was recognised that it is a manageable problem, particularly from a post-closure perspective.

“It is a manageable problem associated with dust from active coal mines or where you have unrehabilitated dumps, particularly of carbonated waste that combusts and gets fires - that can be overcome if its rehabilitated”- Participant 9. Participants 3 and 10 also referred to the

use of coal wastes for domestic purposes as another significant cause of human health problems (such as cardiovascular diseases, sinuses, asthma). This was due to the fact that most of the people do not have electricity and the available coal dumps are re-mined not only for self-use but also for making a living.

“The people there do not have electricity so they burn the coal and make imbawulas”- Participant 10

Participant 6 spoke of Persistent Organic Pollutants and their propensity to cause cancer, and believed that epidemiological studies still have to be done to determine the associated health risks.

Drinking of water polluted with AMD and ingestion of contaminated crops were also noted as major causes of health problems such as impairment in cognitive function, skin lesions, neural defects in foetus development (participant 5 and 9). Participant 1 was more concerned about the effects from drinking tap water, expressing that they have gotten sick from stomach-ache after drinking it.

“When you have a stomach-ache and go to the clinic, they advise you to drink borehole water instead of tap water. At some point a nurse resigned after revealing that they are trained not to inform us what really it is in the water that is making us ill”-Participant 1

- **Livestock Production**

As shown in Figure 3-5, overall the ratings varied amongst participants, with the professional environmental consultants (participants 6, 7 and 8) rating the risks lower than the community and CSO representatives. However, participant 8 was open about his limited knowledge in this aspect, particularly regarding contaminants that can go via the food chain, and believed that proper research on the impact on livestock production (and human health) still has to be done. Furthermore, whilst participants 6 and 7 did not necessarily rate livestock health as a major problem, they did mention that this could become a problem if livestock grazing areas are near the mining facilities.

“Coal dust could have grazing effects - Participant 7”

Participant 10 was in support of this statement and explained that coal dust may fall on fodder that livestock feed on and this may affect the quality and milk production of the livestock.

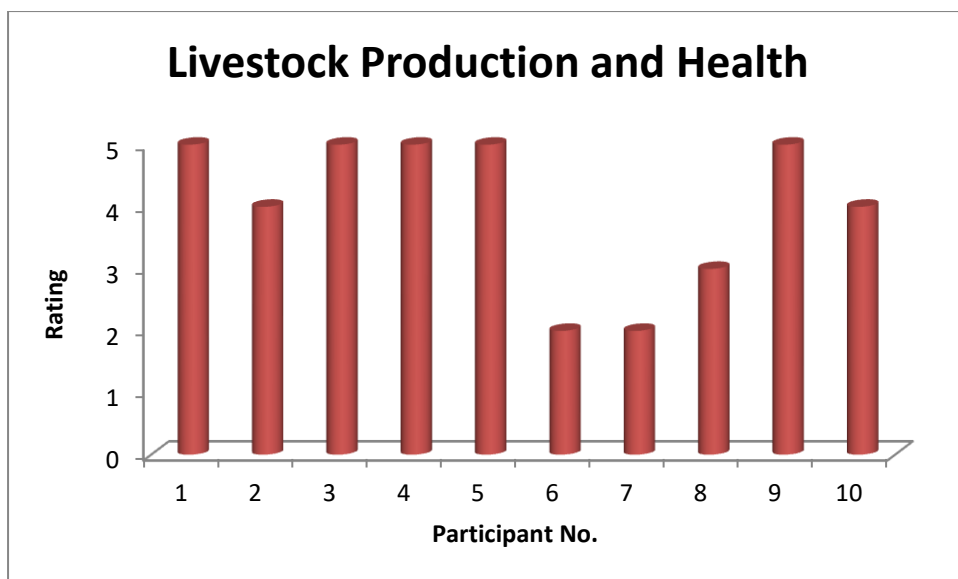


Figure 3-5: Scoring of risk and impacts to livestock production and health

When it came to the issue of livestock production and health, 30% of the participants also attributed this to the pollution of water sources.

“Many of the farmers in Mpumalanga are complaining of their livestock dying from drinking borehole water”- Participant 4

“The livestock there is thin and their skin is patched off”- Participant 1

- **Soil Fertility**

Eighty percent (80%) of the participants considered coal mining to pose a very high risk to soil fertility. Discussions with the participants indicated that soil fertility was looked at from two perspectives: the loss of fertile soil and a decline in soil fertility. The understanding when it came to loss of fertile soil was in relation to the loss of land, coupled with stripping of topsoil during the pre-mining stage. With the exception of participant 5, all of the participants considered the loss of fertile soil to occur mainly as a result of stripping of topsoil at pre-mining stage. The reason for this is that once the topsoil has been stripped off and stockpiled, soil fertility cannot be retained as there is a high chance of mixing with coal and of compaction which renders the soil unproductive. Participants 2 and 6 emphasised that post mining, soil fertility may never be regained.

According to participant 8, the Mpumalanga Province used to have the best yielding soils for maize production but that has changed as a result of coal mining. The decrease in soil

fertility was linked to AMD-polluted water. The polluted water affects the fertility of the soils, mainly due to the high salinity content (participant 5).

- ***Crop Production***

Crop production was generally considered a high (30%) to very high risk (60%) by the participants. Participant 3 admitted having limited understanding of the nature of the impact and rated it a low risk. The risk to crop production was largely linked to soil fertility and most participants referred to this linkage in their responses. Of major concern were the impacts of coal dust fall-out and AMD contamination, with forty per cent (40%) of the participants indicating that the loss in soil fertility from coal dust fallout and AMD contamination resulted in poor crop growth or even failure. The effects of coal dust and AMD are, furthermore, linked to the bioaccumulation of metals contained in AMD-contaminated waters (participant 5 and 8) and in dust fallout (participant 2 and 7).

“Every crop there is black”- Participant 2

“You cannot farm in co-existence of mining”- Participant 4

Coal production was perceived to have a direct effect on maize production in the Mpumalanga Province. According to participant 6, a very large area of the Province’s open-cast workings are situated on the old maize triangle, so a significant proportion is affected and likely to lead to a drop in production. Maize is pH sensitive and when soil acidification takes place, the root tips may stop growing and the crops become stunted (participant 8). This results in a drop the in quality of crops produced and to rising food prices (participant 2 and 10).

“I have a working relationship with the Mpumalanga Agricultural Union. Farmers are complaining about the quality of crops; they fail quality tests and as a result they cannot export. They sell locally and that doesn’t make business sense”- Participant 10

Participants 4 and 10 were of the view that the decrease in soil fertility due to coal mining could ultimately have an impact on national food security.

- ***Aquatic Life***

The impact and risk on aquatic life was rated high to very high by all the participants. All participants’ concerns centred on the pollution of water sources and wetlands in which there is aquatic life. Participant 10 elaborated that the effluent from the coal mines is offloaded into

the streams and rivers. According to participants 5 and 7, the acidity and toxicity in AMD polluted water decants the water quality and may have a negative, fatal impact on aquatic biota.

“There is nothing living, people are no longer fishing”- Participant 1

“Serious impacts on aquatic life do happen and will continue to happen in that area”- Participant 6

Although participants 6 and 8 shared the same sentiments as the rest, they still felt that there are some aquatic populations in the presence of pollution (participant 6) and that aquatic life is resilient, *“it can survive 100 years of mining:”- Participant 8.*

3.2.2 Other Impacts and Risks Relating to Coal Mining

Participants were asked if they were aware of any other risks and impacts in addition to those listed in the questionnaire. Participants found it a little difficult to add to the already listed risks and impacts, expressing that those were the major issues of concern. Nonetheless, additional concerns were raised about resettlement, immigration, and infrastructure, including the impact on houses and roads and social consequences (Table 3-3).

Table 3-3: Other issues of concern

	<i>Number of participants</i>
Trucks on roads & accidents	3
Blasting	3
Economic benefit	3
Immigration issues (overcrowding, provision of services, health & diseases)	3
Resettlement	2
Future impacts	3

One of the additional issues raised was that of blasting. Blasting during mining operations is said to have a detrimental impact on houses, with participants reporting that most houses and windows were cracked.

Participant 5 referred to open shafts and blasting as a physical and wellbeing risk. *“I know of a family with a disabled child whom at each and every blasting would wet (urinate) himself”.*

Road transportation of coal and equipment was also considered problematic due to the lack of adequate infrastructure. According to the participants, most roads are damaged and often cause accidents in the areas. Equally, participants were concerned about resettlement and immigration; in particular, that people are being moved out of sustainable land usually to land with no productive potential. The distress about immigration was that it results in the formation of informal settlements and overcrowding, which in turn impacts on government capacity to provide services and leads to other issues such as prostitution, ill health and other socio-economic problems.

“The social fabric of society - resettlement results in the loss of sense of place.”- Participant 7

Participant 7 was apprehensive about the welfare of people once they have been relocated: *“It is difficult to ensure that people are as well-off or better-off”*.

Other problems listed were a lack of future planning during the life of a mine by mining companies in terms of long term impact of the mining activities, and failure to invest in other sector activities which may present multiple employment opportunities.

“I would go beyond talking about water quality and quantity and soil fertility and start talking about food and water security”- Participant 9

In general participants were very conscious of the negative environmental and socio-economic impacts that mining presents, but seemed uncertain about specific incidents, with the community representatives saying that there were *“too many to choose from”*. The general feeling was that mining companies enter communities and promise socio-economic development, whereas the outcome is opposite.

“Mining shifts the costs to communities”- Participant 2

“Instead of mining wealth trickling down to communities, it exacerbates poverty”- Participant 5

Participant 8 was certain that mining coupled with political opportunism has and will always have an impact on the community. *“I can give you direct evidence: the village of Mudimeli in Limpopo, a complicated community. On the one hand, there was forced migration during the apartheid area and on the other hand is the deep embedded ancient Venda culture and land*

claims issues to top it all. It became a messy business that made that area uninvestable. Mining will always create tensions there”.

One specific issue that participant 5 cited was that of traditional leadership making decisions for communities by entering into agreements with mining companies when, in actual fact, the benefits are not ploughed back to them.

3.3 Stakeholder Experiences on Communication and Engagement

The study also sought to establish the extent to which community concerns and incidents had been reported, and the perceptions in terms of the responses that these reports had received from the government and mining industry.

3.3.1 Reporting of Concerns and Incidents

Participants were asked if the concerns and incidents pertaining to environmental and community impacts (as documented in Section 3.2) had been reported, and were requested to provide details in terms of the nature and recipients of these reports. With one exception, all participants mentioned that the concerns and incidents had been well reported. Table 3-4 shows the methods used and stakeholders to whom concerns have been reported as indicated by participants.

Table 3-4: Reporting of concerns and incidents

	<i>Number of Participants</i>
<i>Recipients</i>	
Government Departments	8
Civil Society Organisations	6
Mining corporations/management	4
Local leadership	2
<i>Form of Reporting</i>	
Academic research	4
Media (TV, Radio, Paper)	4
Community meetings & protests	2

Participants indicated that the concerns and incidents have been reported to the respective government departments, local leadership and the mining corporations and their management, through activists' organisation reports, media reports, meetings with mining companies and communities, community protests and academic research. The participants were of the opinion that the community mainly reported concerns to government (80%) at community meetings and through written reports, and directly (verbally) to the CSOs (60%). Forty per cent (40%) of the participants also mentioned that the concerns were reported directly to mining companies and to the general public through media and academic research. According to 20% of the participants, concerns have also been communicated to local leadership through community meetings and protests.

"We have done a number of documentaries, especially on the impact of water"- Participant 4

"Mostly have been reported to mine management where we could"- Participant 7

"Communities raise concerns, they protest from time to time"- Participant 3

"We have reported to the respective departments and to local leadership- Participant 10

However, despite these efforts, most respondents felt that the communities lacked the capability and capacity (both in terms of human and financial capacity) to communicate their concerns effectively.

"Communities are not taken seriously and they do not have the resources and capacity to raise issues in a systematic manner"- Participant 3

"In terms of capacity we are limited, we try as much as we can, everything is documented"- Participant 10

There was also a general perception that the reports had not always been received by the responsible persons and key decision-makers (in mining houses and government).

"Problem is that some of these companies are multi-nationals so the word does not get up the ranks"- Participant 7

This, together with the lack of adequate response from government and mining houses, had served to discourage communities from prioritising reporting. In some instances, this has given rise to what participant 8 termed 'vigilante activism', with certain community activists taking it upon themselves to act in an enforcement role. Hence reporting has become less of a priority by the affected parties.

3.3.2 Current and Emergent Responses to Concerns

Participants were also questioned as to their awareness of any relevant responses to reported concerns, and/or the implementation of impact mitigation actions and strategies on the part of the government and mining houses.

Although the majority of the participants believed that the concerns and incidents have been well reported, the general impression is that community concerns are not being taken seriously by the responsible stakeholders, including government, mining companies and media, and were thus not receiving adequate response.

Three of the ten participants (1, 2 and 3) felt that there has been no response or any plans to mitigate or address the impacts and risks presented by coal mining.

“Nothing has been done, everything has been said verbally”- Participant 1

“The responsible people are never seen, our government doesn’t help one bit; it fails to manage the law and regulations”- Participant 3

“No, they have never been attended to”- Participant 2

It should be noted that this group was comprised mainly of community activists.

Three participants (4, 6 and 10) felt that, whilst there had been some response to concerns, these had been insufficient and did not match the severity of the impacts.

“We have had a lot of public response and not had sufficient responses from government and mining companies. Responses have not been satisfactory and we are worried that government and mining companies are responding appropriately” - Participant 4

“Some of them have been dealt with, some partially and some not at all”- Participant 6

“Response is not sufficient they just appear for a meeting and that’s it”- Participant 10

Participants 5 and 7 felt that, although there is still room for improvement, there have been significant responses in terms of legislative changes and approaches for mitigating the impacts associated with coal mining.

“Quite a lot has been done - water treatment plants, relocation of people and better, alternative livelihoods...rehabilitation should be much better done and there are a lot of technologies that can be applied”- Participant 7.

“There have been some successes; we have influenced amendments to some policies and regulations, although they came at a cost. For example water use licence and compliance reports are now made available and mining companies (upon application for a mining right) have to make financial provision for the impacts (pumping and treatment of mine waste) throughout the life of the mine and post closure”- Participant 5

According to these participants, some of these interventions had already reduced impacts while others could be expected to do so in the future. Participant 5 mentioned having had success in influencing amendments in waste regulations, to include the retrospective application of the “polluter pays principle” and in influencing the decisions to have water use licences and compliance reports available at the DWS.

A further two participants (8 and 9) admitted to being uncertain as to how extensive or effective the responses to community concerns had been.

“There have been too many allegations that the Government doesn’t act as much as they would like them to”- Participant 8

“...we have seen it is not a responsible industry although it paints itself as a highly responsible industry”- Participant 9.

Overall, participants were impressed with the work done by civil society organisations (although more was suggested) in terms of supporting communities, but were less impressed by the efforts of the mining corporations and, particularly, the government, in addressing community concerns in the context of coal mining impacts.

The lack of adequate intervention was, furthermore, attributed largely to unethical arrangements between government officials, as well as community leaders, with mining corporations. Thirty percent (30%) of the participants expressed concern that the mining companies were not complying with regulations, as they were being unduly favoured by government due to these arrangements.

“We do not have any regulators checking to see that rehabilitation is properly done which means mining companies are left to their own devices... “Participant 9

“Government is not doing its role, we cannot trust government on their own because senior employees in government are all mine managers”- Participant 3

“Government should enforce its mandate, our worst enemy at the moment is Government more than the mining companies - there is political interference and that often results in no enforcement”- Participant 5

Participant 9 mentioned that there are a number of class actions in progress, indicating that there is on-going conflict and that this is seen to be a long-term struggle.

“We have lots of pending cases, litigation is a long term battle”- Participant 9

3.4 Stakeholder Aspirations and Expectations

This section of the dissertation explores the participants’ expectations in terms of stakeholder roles and actions in addressing future impacts.

3.4.1 Stakeholder Roles

The interviews provided insights into the perceived roles and interactions between government, civil society organisations and mining corporations in addressing the impacts and liabilities associated with both active and abandoned mines. The majority of participants suggested a joint initiative between civil society, mining corporations and government in order to address and effectively mitigate the environmental and social impacts of coal mining in the Mpumalanga Province.

“It is possible to have a relationship between the three, to help and support each other”- Participant 9

Further details on the perceived roles of each sector are outlined in the sub-sections below.

- ***Role of Civil Society Organisations***

Overall, the participants felt that CSOs should be playing a surveillance role, particularly in terms of holding mining companies accountable for their social and environmental externalities. Some concern was, however, expressed over the degree of influence of CSOs over government and mining corporations. It was proposed that CSOs are given more recognition in order to enable them to play a more *“sophisticated role”* in managing and engaging government and mining corporations (participant 3).

“Civil society is doing enough but the problem is that they are not the ones to take action against the mining companies, their roles is just to capacitate communities”- Participant 2

“They should join government in holding mining accountable”- Participant 7

- ***Role of Mining Corporations***

Mining corporations were largely expected to comply with government laws and regulations and requirements, relating in particular to the acquisition of the necessary licences and adherence to the licensing conditions, and to the general principles of good governance in terms of their social and environmental obligations (90% of participants).

“They should adhere to social and labour plans; and integrate them with IDP Municipalities even though that has been highly politicised to address the needs of politicians”- Participant 5

“Mining companies should be good corporate citizens, apply working codes and comply with licences and ensure that they are not violating environmental rights, particularly the right to water - currently they are not complying because they are not monitored”- Participate 9

The need to apply measures to ensure that there was effective rehabilitation of mining areas was emphasised.

“The environment should be adequately and sustainably rehabilitated”- Participant 4

Companies were also expected to involve mining communities in decision-making and to develop more effective community grievance mechanisms (participants 1 and 2).

Mining companies must consult with communities; they do not consult right now”- Participant 2

- ***Role of Government***

The general feeling was that government should be playing a more prominent role in regulation and enforcement. Figure 3-6 shows the roles that participants thought government should be playing in terms of addressing the community concerns on the impact of coal mining in Mpumalanga.

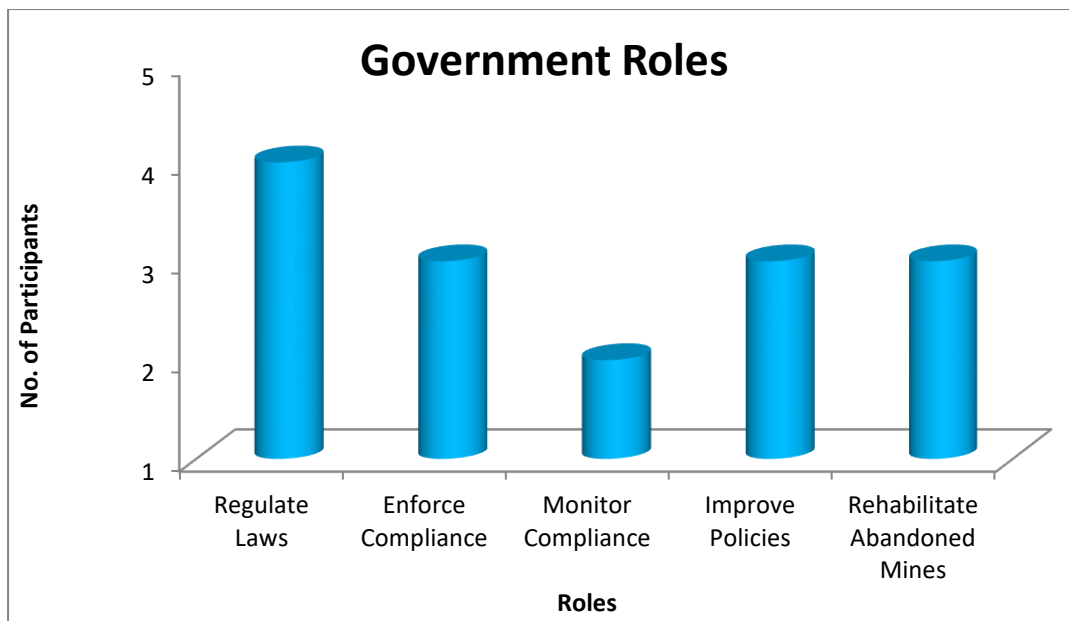


Figure 3-6: Perceived government roles

Participants felt that it was government’s responsibility to improve policies and regulations and to enforce and monitor compliance. They also considered it the responsibility of the government to ensure adequate rehabilitation of abandoned and ownerless mine sites. In general, the participants expressed dissatisfaction with the government’s performance in terms of the above-mentioned roles, attributing this to political interference and unethical relationships between government officials and mining companies (see Section 3.3.2).

“In a normal society, government would be the regulator, mining corporations would be regulated and get their licences, and civil society would play an oversight role - South Africa is not a normal society and will not be with a government made up of a political party having an investment arm”- Participant 8

3.4.2 Future Expectations for Coal Mining

Expectations with regards to the coal mining sector in the future were also interrogated. As indicated in Figure 3-7, 6 out of 10 of the participants felt that coal mining should no longer be practiced at all.

“There’s no future for mining, they have done enough damage”- Participant 1

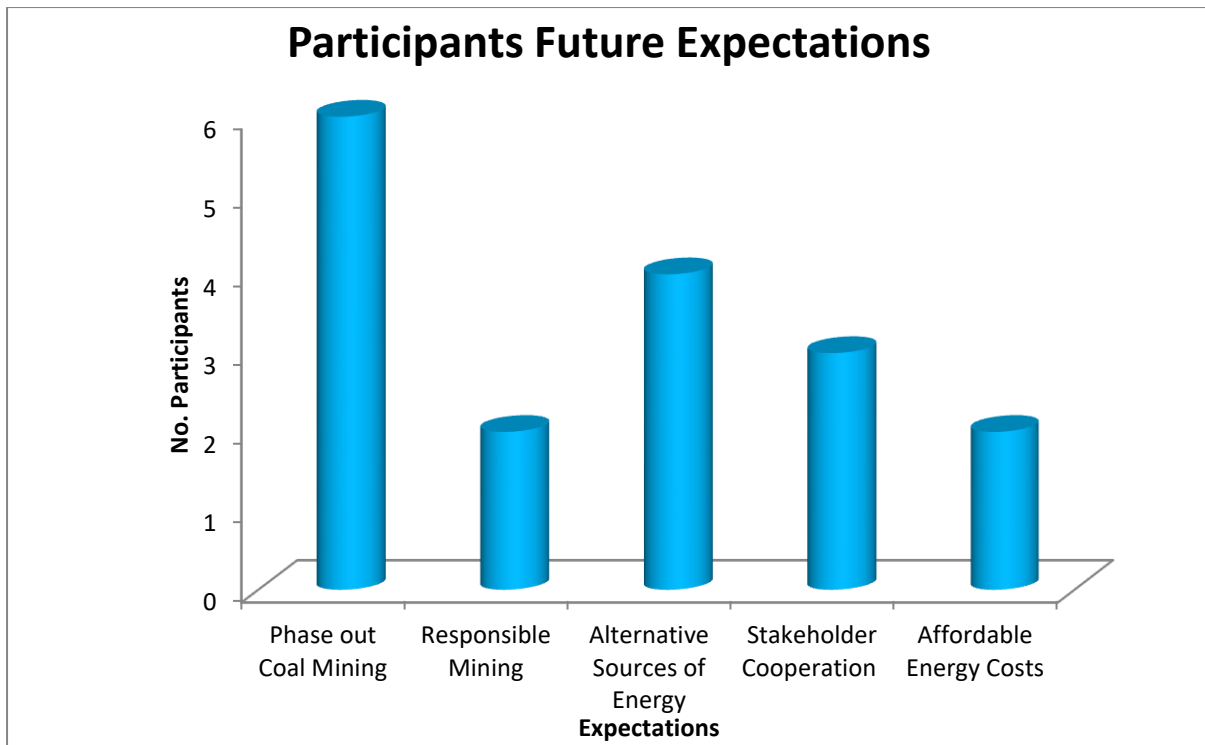


Figure 3-7: Participants future expectations for coal mining

Of these six, four participants felt that a move away from coal mining was necessary for investment in alternative sources which are less destructive to the environment.

“We need to reduce coal mining and increase energy generation from alternatives such as wind and sun energy”- Participant 4

“I would hope that government and the nation start realising that we need to stop extracting fossil fuels from the earth and start looking at alternatives forms of energy because we cannot afford to keep doing what we doing from a climate change point of view and death rates as a direct result of air pollution”- Participant 9

“Government should move to renewable energy where the economy is supported without inflicting pain on the health and lives of people”- Participant 10

Whilst the majority of the participants were anti-mining, other participants still felt that coal mining is essential in terms of providing affordable energy, and should not be phased out altogether. In saying that, two participants mentioned that the coal mining industry ought to operate in a more environmentally and socially responsible manner, particularly in terms of its waste management and the rehabilitation of closed and abandoned mines.

“We need mining companies that are proactive with community needs and with AMD and that will focus on sustainable future land use”- Participant 5

Participants also expected there to be more meaningful engagement between the different stakeholders for mutual benefit:

“I would expect a high road scenario where we have meaningful co-operation between government and mining corporations”- Participant 6

“I hope there will be more cooperation between the different companies for systems like water treatment, rehabilitation, agricultural cooperatives, etc.”- Participant 7

3.5 Summary and Synthesis

This chapter explored perceptions, concerns and experiences regarding the environmental and social impacts of coal mining in the Mpumalanga Province of South Africa, the extent of stakeholder communication and engagement, as well as the aspirations and expectations for the future of coal mining in the region. All participants expressed considerable concern over the environmental and social impacts, and the perceptions of the coal mining and processing sector were largely extremely negative. Community activists were particularly negative and considered coal mining to have a very high negative impact on the local environment and eco-systems, and on human health and activities, such as agriculture and livestock farming. The major concerns amongst all participants related to occupation of land, declining water quality and soil fertility. Land subsidence, destruction of aquatic life, loss of soil fertility and the associated decline in crop productivity were also rated by most of the participants as posing a high to very high risk, followed by air pollution, human health and livestock productivity. Other concerns related to blasting, which causes damage to housing, and the transport of coal, which damages the roads. Generation of AMD both from mining activities and coal dumps was considered to be mainly responsible for the deterioration in water quality and soil fertility, whilst dust (PM) was considered to be the biggest air polluter. Dust containing toxic metals and poor water quality (low pH, high salinity and elevated metals) were also linked to human health issues, and livestock and crop productivity. The negative effect of environmental pollution on maize production in Mpumalanga was of particular concern, with some participants predicting that this could potentially impact on national food security. Communities reported visible evidence of AMD and testified to the tap water being

of such low quality that it made them sick. Also of concern from a health risk perspective was informal “mining” and the use of coal waste by the communities.

All participants considered that the concerns and incidents were all well reported, particularly to government departments and activist organisations. However, the general perception was that the concerns of communities and community-support organisations were not being taken seriously by mining companies and government in particular, and that these reports had not been very successful in terms of soliciting adequate responses and actions. Interviewed community activists, in particular, felt that there had been absolutely no response from mining companies and government to their concerns. Others acknowledged that there had been some effort by mining companies and government to address the environmental and social impacts, with highlighted activities including treatment of AMD-contaminated mine water and revisions of legislative regulations. Whilst relocation of people from the close proximity of mining operations has also been put into practice, and is seen as a viable way of breaking the mine pollution-community effect chain, resettlement of communities is fraught with controversy and is a major concern for community members and community support organisations. In short, the general consensus appeared to be that, despite extensive efforts from civil society organisations to support affected communities in the Mpumalanga area, government and mining companies were failing to alleviate the environmental degradation and human suffering in the area. The lack of adequate intervention on the part of both the government and industry was, furthermore, attributed largely to the unethical arrangements between government officials and/or community leaders with mining corporations. A number of participants felt that government was failing to enforce regulations due to its close relationship with the mining industry, a situation that the mining companies were exploiting.

In terms of the expectations and aspirations of communities regarding actions and responses going forward, there is general feeling that effective rehabilitation is a key requirement in terms of mitigating the environmental impacts and associated risks pertaining to human and livestock health and crop productivity. Conversely poor rehabilitation was seen to be contributor to environmental pollution and associated risks. This pertained not only to current operations but also to abandoned mines—the rehabilitation of which was seen to be the responsibility of the government. Participants also stressed the need for more effective and consistent implementation and enforcement of regulations designed to protect the environment and society, and the need for different stakeholders (government, mining

companies and civil society organisations) to collaborate and co-operate. However, the recognised opportunities to minimise the impacts of coal mining notwithstanding, most participants felt that coal-based power generation should be phased out and replaced with alternative (and cheaper) sources of energy. This would then negate the need for coal mining in the future, which was seen to be a desirable outcome. None of the participants seemed to consider coal mining to deliver any benefits to local communities.

Participants' concerns further suggested issues of disruption in social and cultural norms, and economic changes particularly crime and safety, unemployment, health, and food and water security. It is also interesting to note that whilst there is a general understanding of the cause-effect relationships, participants provided limited evidence-based examples of where such relationships had manifested themselves in the context of coal mining in the Mpumalanga area.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

This study set out to investigate the relationship between coal mining, environmental degradation and community impacts. The main objective was to investigate the facts, perceptions, concerns and conflicts in the mine-environment-community cause-effect chain in order to provide a detailed understanding of the interrelationship between coal mining, the environment and community quality of life in terms of health and livelihoods. This was undertaken in two phases: phase 1 was a desktop study involving a survey and detailed review of environmental and related social impacts of coal mining and processing, and associated incidents and conflicts between local coal mining companies and communities; and the actions taken by various stakeholders to address these impacts. Phase 2 entailed semi-structured interviews with representatives from community, civil society organisations and independent environmental consultants to establish the perceptions and concerns amongst communities with respect to the mine-environment-community cause-effect chain and to assess issues of information, communication and responses in terms of these concerns.

The purpose of this chapter is to consolidate and discuss the results from the study (presented in Chapter 2 and Chapter 3) and their implications. The chapter also draws conclusions from the research work and makes recommendations for supporting the development and implementation of sustainable solutions to the issues identified.

4.1 Key Findings: A Summary and Synthesis

4.1.1 The Interrelationship between Coal Mining, Environmental Degradation and Community Well-Being

The review of the published literature, including academic literature, media articles and civil society organisation reports, bears testimony to the adverse impacts of coal mining on the local environment (air, water and land) and the adverse effects of such on eco-systems and the health and livelihoods of local communities, particularly in terms of livestock farming and agriculture. These literature findings were, furthermore found to be largely consistent

with the perceptions and concerns of communities, community support groups and consultants active in the coal-mining regions of Mpumalanga Province. Emissions, particularly AMD and dust, from current and defunct workings and waste piles continue to be a source of water pollution, air pollution and land degradation (through subsidence and erosion). The degradation and pollution linked to AMD contamination, in particular, (as shown in Figure 4-1), has an adverse effect on aquatic life and human health as well as on livestock and crop productivity (Figure 4-1).

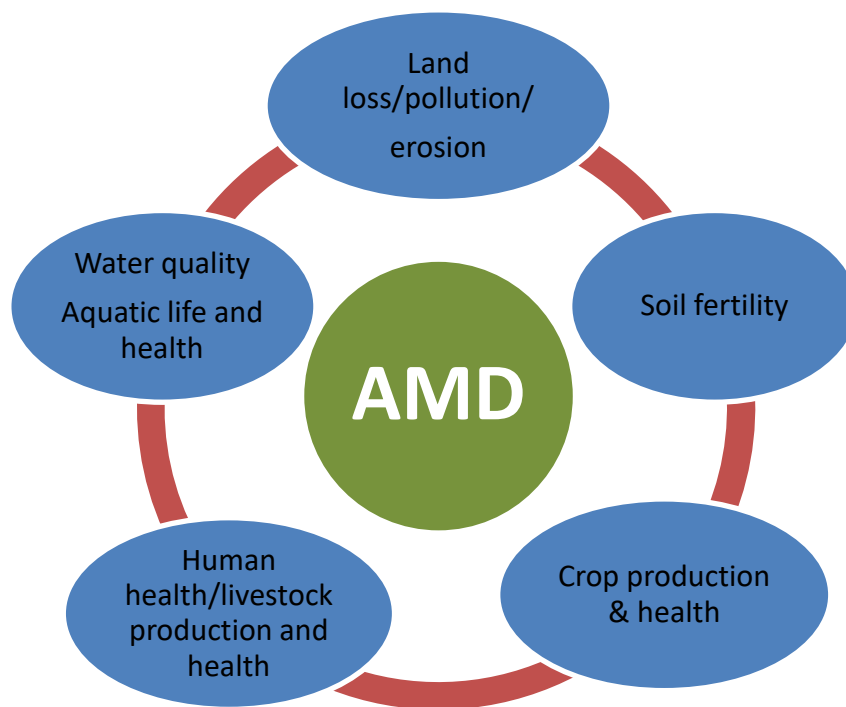


Figure 4-1: AMD linkages

Of particular concern in the coal-mining-intensive area of Mpumalanga, is the impact of environmental pollution on maize production. Other direct impacts of concern from coal mining operations include the effects on infrastructure due to blasting and road haulage, and the health risks associated with the use of coal waste as a source of fuel. However, despite the abundance of generic scientific evidence of the relationship between mining activities, environmental pollution, and the health of humans, livestock and crops, no specific studies appear to have been done to quantitatively establish cause-effect or source-receptor linkages in the South African context. Indeed, there appears to be little quantitative data and information in the public domain, to support either the written or verbal reports of environmental pollution and related social impacts associated with the local coal mining industry.

4.1.2 Stakeholder Responses, Roles and Relationships

Concerns and incidents relating to the environmental and socio-economic impacts from coal mining in the Mpumalanga area are generally well reported. Communities have reported incidents of impacts to mining companies, government, local leadership and CSOs directly, and through academic and CSO reports, media and community meetings and protests. Specifically, visible evidence of AMD contamination has been mainly reported and considered to be the most significant impact from coal mining. Increasing public knowledge and awareness of these impacts can be largely attributed to the activities of the relatively large number of civil society organisations that now exist with the purpose of protecting the local environment and communities against “injustices” by mining companies. Whilst there are an extensive number of reports from CSOs detailing on the impacts, there is limited reporting on successful interventions. This study has indicated that there has been a response to these concerns by government and the industry. The government has instituted a number of legislative reforms, particularly since 2002, and have established programmes aimed at improving socio-economic challenges in mining towns. Furthermore, a number of multi-nationals have taken steps to improve their environmental performance, in terms of waste management, mine water reclamation and post-closure rehabilitation. However, whilst some participants were aware of these interventions, the general consensus was that the concerns of communities and community-support organisations are not been taken seriously, and that government and industry are failing to alleviate the environmental degradation and human suffering in the Mpumalanga coal-mining areas. This has, furthermore, been attributed largely to the failure of the government to enforce legislation, due to political interference and the unethical relationships between government officials and certain mining corporations and/or traditional leaders.

These perceptions and concerns are consistent with a number of reports in the open literature. The lack of adequate response, and the continuing issues of environmental pollution and adverse community effects, have resulted in on-going (and possibly escalating) conflict situations in the form of community activism, protests and litigation. In the Mpumalanga Province, an increase in the number of incidents and conflicts relating mainly to the impact of water and air pollution and on infrastructure has been observed. A review of past and current incidents indicated that common points of conflict were consistent with perceived risks highlighted by the participants in this study, and include water usage, air and water pollution,

the knock-on effects of these on farming activities, the safety risks posed by abandoned mine voids, and the effect of blasting on buildings.

Apart from enforcement of regulations, government was also seen to be responsible for the rehabilitation of abandoned coal mines and residue deposits. Although it is recognised that effective rehabilitation and post-mine closure has the potential to reduce environmental impacts and associated risks pertaining to human and livestock health, most of the participants felt that the negative aspects of coal mining outweighed any benefits, and should be discontinued completely.

4.2 Concluding Remarks: Gaps, Opportunities and Recommendations

Published literature, along with the lived experiences of communities, and the work experience of other experts, bears testimony to the adverse effect of coal mining on the surrounding environment and the health and well-being of local communities. The lack of site-specific data and source-response or cause-effect case studies to support reported incidents of pollution and related impacts from coal mining in the Mpumalanga area makes it difficult to justify and prioritise interventions to effectively mitigate these impacts. Whilst some of the existing coal mining companies have implemented a number of interventions to reduce the impacts of their operations, abandoned mines and discard dumps, as well as some of the current operations, continue to pollute the environment and impact on local communities.

Although South Africa has advanced policies and regulations, designed to protect the environment and people living in mining communities, governance and implementation remains problematic and highly contentious. This, coupled with inadequate consultation and communication with communities, has led to a situation which is dominated by highly politicised agendas with little factual basis or stakeholder co-operation.

In line with the findings of this study, the following recommendations are made:

- (i) The government address the rehabilitation of abandoned coal mines and discard dumps in the Mpumalanga region as a matter of high priority. Such interventions should be aimed at removing risk in perpetuity, and be linked to regional development plans.

- (ii) Action plans for the rehabilitation of abandoned coal mines be established in collaboration with other stakeholders, including communities, the mining industry and other business sectors in the region.
- (iii) Action plans be based on a comprehensive environmental monitoring programme which develops a better understanding of source-response relationships, and, on this basis, identifies key areas of concern and rehabilitation priorities.
- (iv) A more detailed study be conducted on opportunities to improve the quality and availability of performance reporting by the coal industry.

REFERENCES

ActionAid, 2014. South African coal mining; dirty power at whose cost? .Report on coal mining in Mpumalanga Province. Johannesburg: South Africa.

Akcil, A. and Koldas, S. 2006. Acid mine drainage (AMD): causes, treatment and case studies. *Journal of Cleaner Production* 14:1139-1145.

Anderson, A., Cook, G., and Bax, N. 2014. Mining and Biodiversity. In: Biodiversity: Science and Solutions for Australia. Morton S., Sheppard, A. and Lonsdale, M., Eds. Collingwood: CSIRO Publishing. 167–178.

Aneja, V.P., Isherwood, A. and Morgan, P. 2012. Characterization of particulate matter (PM₁₀) related to surface coal mining operations in Appalachia. *Atmospheric Environment* 54: 496-501.

ACARP (Australian Coal Association Research Program). 2006. Trace elements in coal. Prepared by Dale, L. based on research carried out by CSIRO energy technology, Australia. [Online] Available at: <http://www.acarp.com.au/Media/ACARP-WP-3-TraceElementsinCoal.pdf>.

Balmer, M. 2007. Household coal use in an urban township in South Africa. *Journal of Energy in Southern Africa* 18(3): 27-32.

Becker, E. 2015. Mine protests hit Somkhele. Zululand Observer, 13 May. [Online] Available at: <https://www.moneyweb.co.za/news/industry/waste-legislation-could-cost-mining-companies/>.

Bell, F.G.B., Bullock, S.E.T., Halbach, T.F.J. and Lindsay, P. 2001.Environmental impacts associated with an abandoned mine in the Witbank coalfield, South Africa. *International Journal of Geology* 45:195-216.

Bench Marks Foundation. 2014. South African coal mining: corporate grievance mechanisms, community engagement concerns and mining impacts. Policy Gap Report No. 9. Johannesburg: South Africa.

Bench Marks Foundation and Bread for All. 2015. *Vitol and coal trading: challenges of human rights due diligence in the supply chain*. Joint work of the research teams of Bench Marks Foundation and Bread for All (August 2015).

Bergh, K. 2013. South African Coals: Distribution of trace metals. *Inside Mining* 10: 12–14; cited in Broadhurst et al., 2016, op. cit.

Bester, M. and Vermeulen, P.D. 2010. Investigation of potential water quality and quantity impacts associated with mining of the shallow Waterberg coal reserves, west of the Daarby Fault, Limpopo Province, South Africa. *Water SA* 36(5): 531-541.

Biyase, L. 2015a. Bleak harvest for farmers under threat of mining. Sunday Times, 22 November: 03.

Biyase, L. 2015b. Coal scavengers risk lives underground. Sunday Times, 22 November: 03.

Bradford, P. and Salmon, D. 2007. Water management for today and tomorrow: presentation made at the start of the Waterways summit. Johannesburg: South Africa.

Broadhurst, J., Amaral Filho J., Moyo, A., Nwaila, P., Sampa N’Gandu H., Shongwe, B. and Sibanda, L. 2016. Resource efficient and socially responsible approaches for the integrated management of mine waste: understanding the opportunities, enablers, barriers and risks. Second progress report to the Water Research Commission: Report Project No. K5/2580, Department of Chemical Engineering. University of Cape Town.

Brown, J. 2016. Mines and state set for battle over charter. [Online] Available at: <http://www.fin24.com/Companies/Mining/mines-and-state-set-for-battle-over-charter-20161125> [27 April 2017].

CER (Centre for Environmental Rights). 2016a. Joint Stakeholders’ submission on: the threats to human rights from mining and coal-fired power production in South Africa. Universal Periodic Review of South Africa, 27th Session (March 2017).

CER (Centre for Environmental Rights). 2016b. *Zero Hour*. Report on poor governance of mining and the violation of environmental rights in Mpumalanga. Cape Town: South Africa.

Chadwick, M.J., Highton, N.H. and Lindman, N. 2013. Environmental impacts of coal mining & utilization: a complete revision of environmental implications of expanded coal utilization. *Business and Economics*: Elsevier.

Chamber of Mines of South Africa and Coaltech Research Association. 2007. Guidelines for the Rehabilitation of Mined Land Handbook 1-124 . Johannesburg: South Africa.

Chen, W., Liu, Y., Huang, X., and Rong, Y. 2005. Respiratory diseases among dust exposed workers. Department of Occupational and Environmental Health, School of Public Health, Tongji Medical College in Huazhong University of Science & Technology, China.

Cohn, C.A., Laffers, R., Simon, S.R., O’Riordan, T. and Schoonen, M. 2006. Role of pyrite in formation of hydroxyl radicals in coal: possible implications for human health. *Particle and Fibre Toxicology* 3:16.

Colagiuri, R., Cochrane J., and Girgis S. 2012. *Health and Social Harms of Coal Mining in Local Communities: Spotlight on the Hunter Region*. Beyond Zero Emissions, Melbourne, October 2012.

Colagiuri, R. and Morrice, E. 2015. Do coal-related health harms constitute a resource curse? A case study from Australia’s Hunter Valley. *The Extractive Industries and Society* 2:252-263.

Cogho, V. 2012. Optimum coal mine water reclamation plant. Powerpoint presentation, Optimum Coal Holdings, Mpumalanga.

Cogho, V.E. and Karakatsanis, E. 2010. Drinking water from mine water using the HiPRO process-Optimum coal mine water reclamation plant. *Mine water & innovative thinking: Proceedings of the International Mine Water Association Symposium*. Sydney, Nova Scotia, Canada, 5-9 September.

Cvetkovic, Z., Logar, M., Rosic, A. and Ciric, A. 2012. Mineral composition of the airborne particles in the coal dust and fly ash of the Kolubara basin (Serbia). *An International Journal of Mineralogy, Crystallography, Geochemistry, Ore Deposits, Petrology, Volcanology* (81) (2):205-223.

Dai, S., Tian, L., Chou, C.L., Zhou, Y., Zhang, M., Zhao, L., Wang, J., Yang, Z., Cao, H and Ren, D. 2008. Mineralogical and compositional characteristics of Late Permian coals from an area of high lung cancer rate in Xuan Wei, Yunnan, China: Occurrence and origin of quartz and chamosite. *International Journal of Coal Geology* 76(4): 318-327; cited in Rout, et al., 2014, op. cit.

Davis, R. and Franks, D. 2014. Costs of company-community conflict in the extractive industry. Report No 66, Corporate Social Reporting Initiative, Harvard Kennedy School, Cambridge, MA.

De Klerk, A. 2016. Research into ecological infrastructure steps up gear: ecological infrastructure. *The Water Wheel* 15(3):24-27.

De Korte, G.J. 2004. Coal beneficiation in South Africa— past, present and future. International Organising Committee for the XV International Coal Preparation Congress, China, 19 April 2004; cited in Broadhurst et al., 2016, op. cit.

Demacon Market Studies. 2016. Alexander Economic Impact Assessment Report. Waterkloof: South Africa. [Online] Available at: <http://www.sahra.or.za/sahris/sites/default/additionaldocs/Appendix%20U%20-%20Economic.pdf> [03 March 2017].

DEA (Department of Environmental Affairs). 2012. National waste information baseline report. Department of Environmental Affairs. Pretoria, South Africa.

DEA (Department of Environmental Affairs). 2011. The Highveld priority area air quality management plan (Draft Plan).

Diale, A.J. 2014. Corporate social responsibility in the South African mining industry: necessity, conformity or convenience. *International Journal of Business and Economic Development* 2(1): 16-26.

Digby Wells Environmental. 2013. *Environmental regulatory process for Sigma colliery ash backfilling*. Background information document prepared for Sasol Mining (Pty) Ltd.

Dlamini, T.S. 2007. Analysis of trace gas emissions from spontaneous coal combustion at a South African colliery. Unpublished Master's dissertation. University of the Witwatersrand: School of Geography, Archaeology and Environmental Studies.

DME (Department of Minerals and Energy). 2001. *National inventory discard and duff coal*, Pretoria: Department of Minerals and Energy, Pretoria; cited in Kotelo, 2013, op. cit.

DME (Department of Minerals and Energy). 2007. *Sustainable development in mining initiative development of indicators for monitoring the contribution of the South African mining and minerals sector to sustainable development*, Pretoria: Department of Minerals and Energy.

DPME (Department of Planning, Monitoring and Evaluation). 2017. Overview of the Special Presidential Package for the Revitalisation of Distressed Communities.

Draft Mining Charter. 2016. Draft reviewed broad based black economic empowerment Charter for the South African Mining and Minerals Industry. *Government Gazette*. 610(39933). 15 April. Pretoria: Government Printers.

Duus, S. 2013. Coal contestations: learning from a long, broad view. *Rural Society* 22(2):96-110.

DWA (Department of Water Affairs. 2013). A Desktop Assessment of the Present Ecological State, Ecological Importance and Ecological Sensitivity per Sub Quaternary Reaches for Secondary Catchments in South Africa. Compiled by RQS-RDM; cited in WRC, 2017, op.cit.

Eberhard, A. 2011. The future of South African coal: market, investment, and policy challenges. Working paper for the program on energy and sustainable development (January 2011).

eMalahleni. 2014. SACN Report. [Online] Available at: <http://www.sacities.net/wp-content/uploads/2015/10/Emalahleni-final-report-author-tc.pdf>. [03 March 2017].

EJA (Environmental Justice Atlas). 2016. *Leave the coal in the hole (South Africa)*. [Online] Available at: <https://ejatlas.org/conflict/fuleni-mine/>. [06 December 2016].

Feris, L. and Kotze, L.J. 2014. The regulation of acid mine drainage in South Africa: law and governance perspectives. *Potchefstroom Electronic Law Journal* 17(5):2105-2163.

Finkelman, B.R. 2004. Potential health impacts of burning coal beds and waste banks. *International Journal of Coal Geology* 59:19-24.

Finkelman, B.R., Orem, W., Castranova, V., Tatu, C.A, Belkin, H.E, Zheng, B., Lerch, H.E., Maharaj, S.V. and Bates, A.L. 2002. Health impacts of coal and coal use: possible solutions. *International Journal of Coal Geology* 50:425-443.

Gamu, J., Le Billon, P. and Spiegel, S. 2015. Extractive industries and poverty: a review of recent findings and linkage mechanisms. *The Extractive Industries and Society* 2:162-176.

GDACE (Gauteng Department of Agriculture, Environment and Conservation). 2008. Mining and environmental impact guide. Report produced by Digby Wells and Associates, Growth Lab and Council for Geoscience. Johannesburg.

Greenpeace International. 2008. The true cost of coal: how people and the planet are paying the price for the world's dirtiest fuel. Amsterdam: The Netherlands.

GroundUp and Davies, T. 2014. *Mpumalanga crisis: why is nobody listening?* [Online] Available at: http://www.groundup.org.za/media/features/mpumalanga/mpumalanga_0002.html. [18 July 2016].

GroundWork Report. 2016. The destruction of the Highveld. Part 1: Digging coal. Pietermaritzburg: South Africa. Available at: <https://lifeaftercoal.org.za/wp-content/uploads/2016/11/gWReport-2016.pdf>.

Hancox, P.J. 2016. The coalfields of South-Central Africa: A current perspective. *Episodes* 3 (2):407-428.

Hartnady, C. 2010. South Africa's diminishing coal reserves. *South African Journal of Science* 106 (9/10):1-5.

Hendryx, M. 2015. The public health impacts of surface coal mining. *The Extractive Industries and Society* 2(4): 820-826.

Hendryx, M., O' Donnell, K. and Horn, K. 2008. Lung cancer mortality is elevated in coal-mining areas of Appalachia. *Lung Cancer* 62: 1-7.

Hutton, B., Kahan, I., Naidu, T. and Gunther, P. 2009. Operating and maintenance experience at the eMalahleni Water Reclamation Plant. Abstracts of the International Mine Water Conference Proceedings, Pretoria, South Africa, 19-23 October. Available at: https://www.imwa.info/docs/imwa_2009/IMWA2009_Hutton.pdf.

Hota, P. and Behera, B. 2015. Coal Mining in Odisha: An analysis of impacts on agricultural production and human health. *The Extractive Industries and Society* 2(4):683-693.

Howard, J. 2016. Coal mining and the ongoing crisis: economics, finance, and risk. *Inside Mining* 9(8):8-9.

ICMM (International Council on Mining and Metals). 2015. Research on company-community conflict. Social and Economic Development InBrief report. London: United Kingdom.

Jeffrey, L. 2005a. Challenges associated with further development of the Waterberg coalfield. *Journal of the South African Institute of Mining and Metallurgy* 105:453-458.

Jeffrey, L. 2005b. Characterization of the coal resources of South Africa. *Journal of the South African Institute of Mining and Metallurgy* 105:95-102.

Jennings, S.R., Neuman, D.R. and Blicher, P.S. 2008. Acid mine drainage and effects on fish health and ecology: A Review. Reclamation Research Group Publication, Bozeman, MT.

Jolly, T. 2014. Mine protests hit Somkhele. Zululand Observer, 22 November. Available at: <http://zululandobserver.co.za/52438/mine-protests-hit-somkhele/>.

Khosa, N. 2017. Looking at the feasibility of the “One Environmental System”. Mining Online, 23 March. [Online] Available at: <http://www.miningafricaonline.co.za/index.php/mining-features/sustainability/3216-looking-at-the-feasibility-of-the-one-environmental-system>.

Kitula, A.G.N. 2006. The environmental and socio-economic impacts of mining on local livelihoods: A case study of Geita. *Journal of Cleaner Production* 14:405-414.

Kotelo, L.O. 2013. Characterizing the acid mine drainage potential of fine coal wastes. MSc. in Chemical Engineering Dissertation, Department of Chemical Engineering, University of Cape Town.

Kriel makes major breakthrough in land rehabilitation. 2016. [Online] Available: <http://www.angloamerican.com/media/our-stories/kriel-land-rehabilitation-soya> [03 March 2017].

Laney, A. S., and Weissman, D.N. 2014. Respiratory diseases caused by coal mine dust. *Journal of Occupational and Environmental Medicine* 56 (10).

Lechner, A.M., Kassulke, O. and Unger, C. 2016. Spatial assessment of open cut coal mining progressive rehabilitation to support the monitoring of rehabilitation liabilities. *Resources Policy* 50(c):234-243.

Limpitlaw, D., Aken, M., Lodewijks, H. and Viljoen, J. 2005. Post-mining rehabilitation, land use and pollution at collieries in South Africa. Presented at the Colloquium: Sustainable Development in the life of coal mining. Boksburg, 13 July.

Lloyd, J.P. 2002. Coal mining and the environment. Paper presented at the annual International Bar Association Conference, Durban, South Africa, 20-25 October.

Mangena, S. J. and Brent, A.C. 2006. Application of a life cycle impact assessment framework to evaluate and compare environmental performances with economic values of supplied coal products. *Journal of Cleaner Production* 14:1071-1084.

Mavis, J. 2003. Water use in industries of the future: mining industry. In: *Industrial Water Management: a systems approach*, 2nd Edition, prepared by CH2M HILL for the center for waste reduction technologies, American Institute of Chemical Engineers, New York.

McCarthy, T.S. 2011. The impact of acid mine drainage in South Africa. *South African Journal of Science* 107(5/6):1-7.

McCarthy, T.S. and Humphries, M.S. 2013. Contamination of the water supply to the town of Carolina, Mpumalanga. *South African Journal of Science* 109(9/10):1-10.

McCarthy, T.S. and Pretorius, K. 2009. Coal mining on the Highveld and its implications for future water quality in the Vaal river system. Abstracts of the International Mine Water Conference. Pretoria, 19th -23rd October. Available at: http://imwa.de/docs/imwa_2009/IMWA2009_McCarthy.pdf.

Miningmx. 2015. Mining leaders worry Phakisa is just talk. [Online] Available: <http://www.miningmx.com/news/markets/14256-mining-leaders-worry-phakisa-is-just-talk/>. [27 April 2017].

Mining Review Africa. 2016. New mine rehabilitation regulations prove difficult to implement. [Online] Available at: https://www.miningreview.com/magazine_articles/new-mine-rehabilitation-regulations-prove-difficult-implement/. [04 March 2017].

Mining Weekly. 2010. A brief look at SA's coal mining industry. [Online] Available: http://www.miningweekly.com/article/a-brief-look-at-sas-coal-mining-industry-2010-09-03/rep_id:3650. [12 December 2016].

Mining Weekly. 2017. Anglo sells coal mines to Mike Teke's Seriti. [Online] Available: <http://www.miningweekly.com/article/anglo-sells-coal-mines-to-mike-tekes-seriti> [04 April 2017].

Mining Weekly. 2015. Mining Phakisa can help unlock mining, exploration investment-chamber. [Online] Available: http://www.miningweekly.com/article/mining-phakisa-can-help-unlock-mining-exploration-investment-chamber-2015-08-21/rep_id:3650. [27 April 2017].

Mishra, P.P. 2009. Coal mining and rural livelihoods: case of the Ib valley coalfield, Orissa. *Economic and Political Weekly* 44(44):117-123.

Moffat, S. and Mulloli, T.P. 2003. It wasn't the plaque we expected. Parents' perceptions of the health and environmental impact of open-cast coal mining. *Social Science and Medicine* 57:437-451.

Mokgalaka, R. 2015. Do not take what belongs to us *Groundwork Newsletter* 17(1):1-2. Available at: <http://www.groundwork.org.za/newsletters/>

Mokgalaka, R. 2016. Uniting coal struggles. *Groundwork Newsletter* 18(3):8-9. [Online] Available at: <http://www.groundwork.org.za/newsletters/>.

Morrice, E. and Colagiuri, R. 2013. Coal mining, social justice and health: a universal conflict of power and priorities. *Health and Place* 19:74-79.

Munnick, V. 2010. The social and environmental consequences of coal mining in South Africa : a case study. A joint initiative of environmental monitoring group, Cape Town, South Africa and Both ENDS, Amsterdam, The Netherlands.

Muir, T. 2017. Garbage disposal. [Online] Available at: <http://www.miningdecisions.com/home/garbage-disposal/> [22 June 2017].

Ngubane, C. 2016. *Somkhele community march against corruption and coal mine* [Online] Available at: <https://saveourwilderness.org/2016/03/17/somkhele-community-march-against-corruption-and-coal-mine/> [05 December 2016].

Oelofse, S. 2008. *Mine water pollution-acid mine decant, effluent and treatment: A consideration of key emerging issues that may impact the state of the environment*. Article prepared for the state of environment reporting. CSIR: Natural Resources and the Environment, Pretoria: South Africa.

[Online] Available at: <http://www.operationphakisa.gov.za/Pages/Home.aspx>. [20 April 2017].

[Online] Available at: <http://www.geoscience.org.za/index.php/publication/downloadable-material>.

OSF (Open Society Foundation for South Africa). 2015. In good company? Conversations around transparency and accountability in South Africa's extractive sector. Cape Town, South Africa.

Peatfield, D. 2003. Coal and coal preparation in South Africa— A 2002 review. *Journal of the South African Institute of Mining and Metallurgy* 103(6): 355-372.

Peyper, L. 2017. Chamber in the dark over delay in mining charter. [Online] Available at: <http://www.fin24.com/Companies/Mining/mining-charter-chamber-in-the-dark-over-delay-20170405> [27 April 2017].

Pone, J. DN. ,Hein, K. A. A., Stracher,G.B., Annegarn, H.J., Finkelman, R.B., Blake, D.R., McCormarck, J.K. and Schroeder,P. 2007. The spontaneous combustion of coal and its by-products in the Witbank and Sasolburg coalfields of South Africa. *International Journal of Geology* 72:124-140.

Pooe, D. and Mathu, K. 2011. The South African coal mining industry: a need for a more efficient and collaborative supply chain .Vaal University of Technology. *Journal of Transport and Supply Chain Management* 5(1):316-336.

Prinsloo, L. 2014. Miners vs villagers—again. Sunday Times, 23 March: 02.

Progress made in revitalisation of distressed mining towns- Jacob Zuma. [Online] Available at: <http://www.politicsweb.co.za/politics/progress-made-in-revitalisation-of-distressed-mini>[27 April 2017].

Reddick, J. 2006. An investigation of cleaner production opportunities for the South African coal industry. MSc Thesis. University of Cape Town.

Reddick, J.F., Von Blottnitz, H. and Kothuis, B. 2008. Cleaner production in the South African coal mining and processing industry: A case study investigation. *International Journal of Coal Preparation and Utilization* 28(4):224-236.

Rehabilitation activities in South Africa.2017. [Online] Available at: <http://www.glencore.com/sustainability/case-studies/p/rehabilitation-activities-in-south-africa>[03 March 2017].

Retief, C. 2017. One Environmental System (OES). [Online] Available: <http://www.envass.co.za> [08 June 2017].

Rout, T.F., Masto, R.E., Padhy, P.K., George, J., Ram, L.C. and Maity, S. 2014. Dust fall and elemental flux in a coal mining area. *Journal of Geochemical Exploration* 144:443-455.

Rybicka, H.E. 1996. Impact of mining and metallurgical industries on the environment in Poland. *Applied Geochemistry* 11: 3-9.

SACRM (South African Coal Road Map). 2011. Overview of the South African coal value chain: prepared as a basis for the development of the SACRM. The Green House, Cape Town, South Africa.

Sarma, K.2005. Impact of coal mining on vegetation: a case study in Jaintia district of Meghalaya, India. Unpublished Master's Thesis. The Netherlands: International Institute for Geo-Information Science and Earth Observation.

Senkhane, M. 2015. New regulation to go to waste? *Inside Mining* 8 (11): 24-27.

Sergienko, N. 2017. The eMalahleni Water Reclamation Plant in South Africa. [Online] Available at: www.iwa-network.org/filemanager-uploads/WQ. [02 March 2017].

Schneider, K. 2016. South Africa locks onto coal despite water risks, grim market trends. [Online] Available at: <http://www.circleofblue.org/2016/south-africa/south-africa-locks-onto-coal-despite-water-risks-grim-market-trends/>. [21 October 2016].

Schutte, G. 2014. Legislative jigsaw puzzle undermines rights of communities affected by mining pollution [Online] Available at: <http://www.polity.org.za/article/legislative-jigsaw-puzzle-undermines-rights-of-communities-affected-by-mining-pollution-2014-01-27> [24 June 2017].

Simate, G. and Ndlovu, S. 2014. Acid mine drainage: challenges and opportunities. *Journal of Environmental Chemical Engineering* 2:1785-1803.

Sonter, L.J., Moran, C.J., Barret, D.J. and Soares-Filho, B.S. 2014. Processes of land use change in mining regions. *Journal of Cleaner Production* 84:494-501.

The Real Economy Bulletin. 2016. Provincial review 2016: Mpumalanga [Online] Available at: https://www.tips.org.za/images/The_REB_Provincial_Review_2016_Mpumalanga.pdf.

Tiwary, R.K. 2001. Environmental impact of coal mining on water regime and its management. *Water, Air and Soil Pollution* 132:199-2001.

Van der Burgh, G. 2012. The impact of coal mining on agriculture-a pilot study. Launch for the BFAP baseline agricultural outlook 2012-2021.Stellenbosch. [Online] Available: <http://www.maizetrust.co.za/beneficiaryreports/research/marketandproductionresearch>. [01 December 2016].

Van Wyk, D. 2016. Vryheid has abandoned open-cast mines everywhere. [Online] Available: <http://communitymonitors.net/indexcommnet.php/?p=3987>. [21 October 2016].

Vyawahre, A. and Rai, S. 2016. Acid mine drainage: a case study of an Indian coal mine. *International Journal of Scientific Research in Science, Engineering and Technology* 2(2):1297-1301.

Vermeulen, P.D., Usher, B.H. and van Tonder, G.J. 2007. Determination of the impact of coal mine water irrigation on groundwater resources. CoalTech Report: Task No 6.3.1.

Ward, C.R, French, D., Jankowski, J., Riley, K. and Li, Z. 2006. Use of coal in mine backfill and related applications. Research Report 62, School of Biological, Earth and Environmental Sciences. University of South Wales.

WCI (World Coal Institute).2009. The coal resource —a comprehensive overview of coal. [Online] Available at: <http://www.worldcoal.org/resources/wca-publications> [31 November 2015].

World Atlas. 2015. The top ten coal producers worldwide. [Online] Available at: <http://www.worldatlas.com/articles/the-top-10-coal-producers-worldwide.html>[10 December 2015].

WRC (Water Research Commission). 2017. South African mine water atlas: mapping the decision context for the intersection of mining and water resources in South Africa. [Online] Available at: www.wrc.org.za [15 April 2017].

WRI (World Resources Institute). 2014. Appendix 2: Environmental and social impacts of mining. [Online] Available: http://pdf.wri.org/mining_background_literature_review.pdf. [15 September 2015].

WWF (World Wide Fund for Nature). 2011. Coal and water futures in South Africa. The case for protecting headwaters in the Nkangala grasslands. Cape Town: South Africa.

Yende, S.S. 2016. From waste to bricks. City Press, 23 October. [Online] Available: m.news24.com.

Young, G. 2015. Illegal miner dies in rock fall. *The Highvelder*, 11 March.

Younger, P.L. 2004. Environmental impacts of coal mining and associated wastes: a geochemical perspective. *Geological Society*, London: Special Publications 236: 169-209.

Zhengfu, B., Hilary, I., Daniels, J., Otto, F. and Struthers, S. 2010. Environmental issues from coal mining and their solutions. *Mining Science and Technology* 20:0215-0223.

Zheng, B., Ding, Z., Huang, R., Zhu, J., Yu, X., Wand, A., Zhou, D., Mao, D and Su, H. 1999. Issues of health and disease relating to coal use in southwestern China. *International Journal of Coal geology* 40:119-132.

APPENDIX A: Interview Schedule

Survey Questionnaire - Section A

As part of the study, a list of variables (risks/impacts) has been compiled to assess perceptions and understanding. Based on experience, observation and practice would you say that coal mining influences the variables listed and to what degree? This will require you to rate your responses. Rate the risk/impacts from 1-5 with 5 being a very high risk and 1 being a very low risk/impact. Place a cross under the relevant response.

Risk/Impact	1	2	3	4	5
Land occupation/loss					
Subsidence (ground stability)					
Land pollution and erosion					
Air pollution					
Dust					
Water consumption					
Surface water quality					
Underground water quality					
Human health					
Livestock production and health					
Soil fertility					
Crop production and health					
Aquatic life and health					

Interview Questionnaire - Section B

Based on your responses in Section A, please answer the following questions:

1. What is your current understanding of the following risks and impacts in relation to coal mining?

- a) Land occupation/loss
- b) Subsidence (ground stability)
- c) Land pollution and erosion
- d) Air pollution
- e) Water consumption
- f) Water quality
- g) Human health
- h) Livestock production and health
- i) Soil fertility
- j) Crop production and health
- k) Aquatic life and health

2. Are there any other impacts and risks relating to coal mining that you are aware of? If yes, please provide additional details.

3. Would you say these risks/impacts affect you and/or the community at large? If yes, please give details on the effects and specific incidents of which you are aware.

4. Have these concerns or incidents been reported; how and to whom? Give details on your response.

5. Have these concerns been attended to or are there any plans in place? Give details on your response.

6. What roles do you think that government, mining corporations and civil society should be playing in addressing the impacts and liabilities associated with (a) active coal mines (b) abandoned coal mines?
7. What are your future expectations regarding coal mining and the associated risks and impacts in the community (s)?

APPENDIX B: Informed Consent Form

The Impact of Coal Mining on the Environment and Community Quality of Life: A Case Study Investigation of the impacts and conflicts associated with coal mining in the Mpumalanga Province, South Africa.

I, the undersigned, confirm that (please tick as appropriate):

1.	I have understood the objectives of the project, as explained by the researcher.	
2.	I have been given the opportunity to ask questions about the project and my participation.	
3.	I voluntarily agree to participate in the project.	
4.	The procedures regarding confidentiality have been clearly explained to me.	
5.	I agree to the audio recording of this interview.	
6.	I understand that other researchers will have access to this data only if they agree to preserve the confidentiality of the data and if they agreed to the terms I have specified in the form.	

Participant:

Name:

Organisation:

Role:

Signature:

Date:

Researcher:

Name:

Signature:

Date:

APPENDIX C: Ethics Clearance

Application for Approval of Ethics in Research (EIR) Projects Faculty of Engineering and the Built Environment, University of Cape Town

APPLICATION FORM


Please Note:

Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application prior to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: <http://www.ebe.uct.ac.za/ucsr/ebe/research/ethics.pdf>


APPLICANT'S DETAILS	
Name of principal researcher, student or external applicant	Bonisle Nlwando Shongwe
Department	Chemical Engineering
Preferred email address of applicant:	bonisleshongwe@gmail.com
If a Student	Your Degree: e.g., MSc, PhD, etc.,
	MPhil; Sustainable Mineral Resource Development
	Name of Supervisor (if supervised):
	Dr Jennifer Broadhurst
If this is a research contract, indicate the source of funding/sponsorship	Water Research Commission
Project Title	The Impact of Mine Waste on the Environment and Community Quality of Life: A Case Study Investigation of the impacts and conflicts associated with Coal Mining in the Limpopo Province, South Africa

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available; and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

SIGNED BY		Full name	Signature	Date
Principal Researcher/ Student/External applicant	Bonisle N. Shongwe		12 Oct 2016	
APPLICATION APPROVED BY				
Supervisor (where applicable)	J L Broadhurst		12 Oct 2016	

Application for Approval of Ethics in Research (EiR) Projects
Faculty of Engineering and the Built Environment, University of Cape Town

HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section1; and for all Undergraduate research (Including Honours).			
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.	G. Sithole		24/10/2016

APPENDIX D: The Major Coal Producers

Anglo Coal

- has operations in South Africa, Australia, South America and Canada
- operated eight mines at the time of the interviews
- sold New Denmark, New Vaal and Kriel Collieries to Seriti Resources Holdings in 2017
- has a 50/50 interest in Mafube Mine with Exxaro
- has a 23.2% interest in RBCT
- supplies local and export markets

Mine	Open-cast/Underground	Coalfield	Main Market	Production (Mt in 2008)
Goedhoop	U	Witbank	Export	7.5
Greenside	U	Witbank	Export	3.4
Kleinkopje	U	Witbank	Export	4.5
Landau	U	Witbank	Export	4.5
Kriel(Sold)	U	Witbank	Eskom Kriel	10.3
New Denmark (Sold)	U	Highveld	Eskom Tutuka	5.2
Mafube	O		Eskom Arnot	1.7
New Vaal (Sold)	O	Vereeniging-Sasolburg	Eskom Lethabo	17
Isibonelo	O	Highveld	Sasol	5.3
TOTAL				59.4

Source: Eberhard, 2011

Sasol

- operates coal-to-liquids and chemicals plants
- South Africa's third largest coal producer, after Anglo Coal and Exxaro
- operates six coal mines
- Production was about 39 Mt ROM in 2009
- the coal feeds into Sasol Chemical Industries (SCI) at Sasolburg and Sasol Synthetic Fuels (SSF) at Secunda
- the coal supplied to SCI (2 Mtpa) is used to generate electricity and steam
- the coal supplied to SSF is used as gasification feedstock
- Exports 3.5 Mtpa not used for gasification through RBCT

Exxaro

- SA based
- majority black-owned
- a merger of Eyesizwe and certain Iscor/Kumba interests
- has a 50% interest in Mafube mine
- also produces char and related products for the ferroalloy industry
- has an export entitlement at RBCT of 6.3 Mtpa.
- has signed a 40-year coal contract to supply 14.6 Mtpa to Eskom's new coal fired plant, Medupi, from a R9 billion expansion of its Grootgeluk mine.

Mine	Open-cast/Underground	Coalfield	Main Market	Production (Mt) in 2008
Arnot	U	Witbank	Eskom Arnot	5
Matla	U	Witbank	Eskom Matla	14
North Bank Complex	U	Witbank	Dom + export	3
New Clydesdale	U	Witbank	Export	1.4
Leeuwpan	O	Witbank	Export+ metallurgical	3
Inyanda	O	Witbank	Export	1.5
Tshikondeni	U	Soutpansberg	Hardcoking	0.4
Grootgeluk	O	Waterberg	Eskom Matimba	15.3
Grootgeluk	O	Waterberg	Metallurgical	1.5
Grootgeluk	O	Waterberg	Semi-soft coking	2.7
Grootgeluk Mafube 50%	O	Waterberg	Eskom Medupi	14.6
TOTAL				47.8

Source: Eberhard, 2011

BHP Billiton

- has operations in New Mexico in the USA, Australia and South Africa
- has coal exporting interests in Columbia and Indonesia
- operates four primary mining operations in South Africa
- has three processing plants
- sold its Optimum Mine in 2008, along with a 6.5 Mtpa export entitlement at RBCT, in a black economic empowerment deal.

Mine	Open-cast/Underground	Coalfield	Main Market	Production (Mt) in 2008
Middleburg	O	Witbank	Eskom Duvha & Export	12.1
Douglas	O/U	Witbank		4.9
Khutala	U	Witbank	Eskom Kendall	13.3
Klipspruit	O	Witbank	Export	3.4
Optimum(Sold)	O	Witbank	Eskom Hendrina & Export	
TOTAL				45

Source: Eberhard, 2011

Glencore Xstrata

- formed from the merger of Glencore International and Xstrata PLC
- has operations in Australia, South Africa, Colombia and Canada
- holds a 20.9% interest in RBCT

Mine	Open-cast/Underground	Coalfield	Production (Mt) in 2008
Southstock	O	Witbank	0.7
Southstock	U	Witbank	4.6
Mpumalanga: Spitzkop	O/U	Ermelo	1.1
Mpumalanga: Tselentis	O/U	Ermelo	1.3
Impunzi	O	Witbank	2.3
Impunzi	U	Witbank	1.1
Tweforntein	O	Witbank	3.5
Tweforntein	U	Witbank	2.7
Goedgevonden	O	Witbank	2.9
TOTAL			20.2

Source: Eberhard, 2011

APPENDIX E: Metals and inorganic elements occurring in coal and characteristics of coal discard and tailings

Metals and Inorganic elements occurring in Coal (Bergh, 2013; Finkelman et al., 2002; Finkelman, 2004)

Element	Concentration (wt.%)	Modes of Occurrence
Antimony	n/a	Organic association, pyrite and accessory sulphides
Arsenic	3.1-11.4	Pyrite
Barium	≈0.015	Barite and other Ba-bearing minerals
Beryllium	n/a	Organic association
Boron	n/a	Organic association
Cadmium	0.13-0.6	Sphalerite
Chlorine	n/a	Chloride ions in pore water or adsorbed onto macerals
Chromium	0-0.016	Organic association, illites, chromites
Cobalt	n/a	Multiple associations
Copper	n/a	Chalcopyrite, pyrite
Fluorine	n/a	Various minerals
Lead	7-76	Galena
Mercury	0.12-0.9	Pyrite
Manganese	n/a	Carbonates: siderite and ankerite
Molybdenum	n/a	Accessory sulphides, organic association
Nickel	n/a	Multiple associations
Phosphorus	n/a	Phosphates
Selenium	0.8-3	Organic association, pyrite, accessory selenides
Silver	n/a	Sulphides
Thallium	n/a	Pyrite
Thorium	3.1-8.9	Monazite, xenotime, zircon, clay
Tin	n/a	Oxides and sulphides
Vanadium	0-0.128	Clays and organic association
Uranium	1.2-4.7	Organic association, zircon silicates
Zinc	0-0.56	Sphalerite

Where: n/a is denotes not available

Typical characteristics of coal discard and tailings (DME, 2001)

	Discards	Ultra-fine slurry tailings
Calorific value (MJ/kg)	11-14	20-27
Ash (%)	30-60	10-50
Sulphur (%)	1-5	<2
Volatiles (%)	16-24	17-27
Fixed carbon (%)	18-24	41-56